Technical Report

GOVERNMENT OF INDIA
MINISTRY OF WATER RESOURCES
CENTRAL GROUND WATER BOARD

GROUND WATER POLLUTION IN TAMIL NADU

CPL 648893

BY

Dr. B.UMAPATHI, SCIENTIST-B
&
B.B.SAHOO, SCIENTIST-B

SOUTH EASTERN COSTAL REGION
CHENNAI
NOVEMBER 2007

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ACKNOWLEDGEMENT

The authors wish to acknowledge the opportunity given by Shri **Shobh Nath,** Member (EDMM) (Retd.), CGWB and also his encouragement in compilation of the report. Thanks are also to Shri **R.Chakrapaani,** Regional Director (Retd.), CGWB and **Dr.N.Varadaraj,** Regional Director, CGWB, south Eastern Coastal Region, Chennai for their valuable suggestions and guidance in finalizing the report.

The efforts put forth by Shri P.Nandakumaran, Superintending Hydrogeologist, and Dr.S.Suresh Scientist-D, CGWB for their meticulous scrutiny of the report is also gratefully acknowledged.

The hard labour put forth by several Hydroscientists in carrying out the investigations, collection and interpretation of the hydrogeological and hydrochemical data is no small and without which it would not have been possible to prepare this report and is acknowledged sincerely.

The co-operation extended by the Hydroscientists of South Eastern Coastal Region, Chennai is gratefully acknowledged.

The help rendered by A.Ramesh Kumar, STA (Chemist), and Smt.Vijaya Shankar, UDC in preparation of draft report is acknowledged with sincere thanks.

The efforts of Smt. M.Vasuki and M.Navaneetham, Draftswomen, S/shri d.N.Ranganatha and Ajit Singh, Draftsmen, V. Padmanabhan Steno and N.Selvanayagam, Sr.Surveyor of Report Processing Section, south Eastern Coastal Region, in bringing out this report elegantly are no small and are duly acknowledged.

GROUND WATER POLLUTION IN TAMIL NANDU

Chapter - 1

INTRODUCTION

Water is an essential and vital component for our life support system. In tropical regions ground water plays an important role in the context of fluctuating and increasing contamination of surface water resources. Ground water has unique features, which render it particularly suitable for public water supply. It has excellent natural quality, usually free from pathogens, colour and turbidity and can be consumed directly without treatment. Ground water is widely distributed and can be frequently developed incrementally at points near the water demand, thus avoiding the need for large scale storage, treatment and distribution system. Ground water is particularly important as it accounts for about 88% safe drinking water in rural areas, where population is widely dispersed and the infrastructure needed for treatment and transportation of surface water does not exist. Ground water plays an important role in agriculture, for both watering of crops and for irrigation of dry season crops. It is estimated that about 45% of irrigation water requirement is met from ground water sources. Industrial demands for ground water are also high, as many of the qualities which make ground water a preferred source of potable water (low salinity, low turbidity, lack of pathogens) are also important in use of ground water in various industries. Unfortunately, the availability of ground water is not unlimited nor is it protected from deterioration. In most of the instances, the extraction of excessive quantities of ground water has resulted in drying up of wells, damaged ecosystems, land subsidence, salt-water intrusion and depletion of the resource. Ground water quality is being increasingly threatened by agricultural, urban & industrial wastes, which leach or are injected into underlying aquifers.

With the increasing pace of industrialization and urbanization, ground water contamination has become a growing concern globally. People contaminate ground water and it needs to be protected by the people to ensure that clean and safe ground water is available to the society now and in future also. Once it is contaminated, it is very difficult to clean. Contamination in ground water will last for a very long time as a consequence of long residence time of ground water. Furthermore, the time lag between introduction of a contaminant into the hydrologic cycle and its appearance in ground water may deceive the public regarding its real threat to the ground water quality. In order to meet the demands of the growing population, there is an urgent need for proper study of changing ground water quality including ground water pollution. Thus, first it is necessary to understand the meaning of water pollution.

Pollution of water may be defined as " an undesirable change in physical, chemical, physiological or biological characteristics of natural water, directly or indirectly as the result of the activities of man so that they become less useful or will harmfully affect human life or that of any other desirable species, or industrial processes, living conditions or cultural assets or that may or will waste or deteriorate our water resources" (Handa, 1975- As quoted in CGWB 1996).

As a result of our consumptive way of life, the ground water environment is being assaulted with an ever-increasing number of soluble chemicals. As time goes on, the vast ground water reservoir is gradually becoming degraded due to man's activities. The pollution can be point pollution or non-point pollution. In this form, the pollution is caused at a point where as in the latte, it is difficult to specify single point of entrance of pollutants.

The quality of ground water in some parts of the country particularly shallow aquifers (Phreatic zone) is changing gradually as a result of man's activities and has deteriorated in many instances. Municipal and industrial wastes, Chemical fertilizers, herbicides and pesticides enter the soil, infiltrate into the aquifer and degrade ground water quality. Other pollution sources include sewer leakage, faulty septic tank operation and landfill leachates. In some coastal areas, intensive pumping of fresh ground water has caused salt-water intrusion into fresh water aquifers.

Ground water is less susceptible to bacterial pollution than surface water because the soil and rocks through which ground water flows, screen out most of the bacteria. Bacteria, however, occasionally find their way into ground water, sometimes in dangerously high concentrations.

The sources, which are responsible for ground water pollution, are:

URBAN POLLUTON

- Municipal Dumps and sanitary landfills
- Septic tanks and soak pits
- Municipal liquid wastes

INDUSTRIAL POLLUTION

- Industrial solids and liquid waste disposal
- Dumping of solid wastes as landfill
- Petroleum products
- Metal wastes – the seepage of plating wastes containing Cadmium (Cd) and hexavalent Chromium (Cr)
- Disposal of oil filed brines
- Fly ash from thermal power plants

AGRICULTURAL POLLUTION

- Agricultural wastes – plant residues
- Animal wastes – manures
- Fertilizers, Pesticides and Herbicides

SALT-WATER INTRUSION

- Uncontrolled pumping of ground water in coastal areas

POLLUTION DUE TO RADIOACTIVE SUBSTANCES

- Physical pollutants discharged from atomic reactors, mining and milling of radioactive ores, chemical reprocessing etc.

1.1 PURPOSE AND SCOPE

An attempt has been made in this report to compile and processes the data related to contamination of groundwater resources in Tamil Nadu, collected during various investigations carried out by officers of Central Ground Water Board, South Eastern Coastal Region, Chennai over the years. Efforts have also been made to arrive at inferences regarding the spatial and temporal variations in the concentration of various contaminants in ground water. This report is intended to be of use as a reference and guide for administrators, planners and scientists working in the field of sustainable ground water management in Tamil Nadu.

This report is an attempt to bring out various issues related to groundwater pollution threatening the prospects of sustainable groundwater management in Tamil Nadu. Brief descriptions of ground water quality scenario and hydrogeological set up of the state are given in the first two chapters. This followed by detailed discussion on the water quality criteria being adopted for various uses. Various aspects of pollution of ground water by Nitrates are elaborated in *Chapter-4*. This is followed by an account of geogenic ground water quality problems, due to the presence of Fluoride and Arsenic in ground water in particular furnished in Chapter-5. Salient features of various case studies taken up by Central Ground Water Board in Tamil Nadu are provided in the Chapter-6 as "Case Studies". Conclusions and recommendations arrived on the basis of the studies carried out so far have been given in Chapter-7.

1.2 LOCATION AND EXTENT

Tamil Nadu State lies between north latitudes 08^0 00' and 13^0 30' and east longitudes 76^0 15' and 80^0 18'. The State is bounded by Bay of Bengal in the east, the Indian Ocean in the south, Western Ghats in the west and the States of Andhra Pradesh and Karnataka in the north. The total geographical area of State is 1,30,058 Sq. km.

1.3 PHYSIOGRAPHY

Tamil Nadu State can be divided into four physiographic divisions viz., (i) the Coastal Plains, (ii) the Eastern Ghats, (iii) the Central Plateau and (iv) the Western Ghats.

The coastal plains stretch over a distance of 998 km from Pulicat lake in the north to Kanyakukmari in the south with an elevation of 2 to 30 m above MSL. The plains consist of Coromandal Coast in the north, alluvial plains of Cauvery delta in the center and southern plains in Pudukkottai - Kanyakumari belt.

The chain of flat-topped hills of Javadis, the Shevroy; the Kalrayan and Pachamalai hills, which join Cardomom hills in the south form the Eastern Ghats. These hills rise steeply above plateau level to 1160 m above MSL in the Javadi hills to 1645 m above MSL in the Shevroy hills.

The Central plateau located between Western Ghats and Eastern Ghats has an undulating topography with an average elevation of 150 m to 160 m above MSL. West of this region lies the broad Palghat Gap between the Nilgiris and Anaimalai hills. Between Cauvery and the Palghat Gap lies an extensive low plateau rising gradually from 120 to 180 m above MSL.

The plateau is fringed on the west by a group of high hills, namely the Western Ghats. These are the Nilgiris in the north, Anaimalai Hills, Palani and Cardomom hills in the south with a summit level of 1830 to 2440 m above MSL rising sharply from plateau.

1.4 DRAINAGE

Tamil Nadu is drained by a number of major and minor rivers, mostly originating in the Western Ghats and flow eastwards. The main rivers are the Palar, Ponnaiyar, Vellar, Cauvery, Vaigai, Tambraparani, Gundar, Vaippar and Nambiyar. Cauvery and Tambraparani are perennial rivers and the rest are ephemeral. The Cheyyar, Bhavani, Korattalaiyar, Amaravati, Noyil, Aliyar, Sholiyar and Parambikulam are the other small rivers in the State. Pulicat lake and Kaliveli tank are important lagoons.

1.5 CLIMATE AND RAINFALL

Tamil Nadu, basically, has a tropical climate. The maximum temperature in summer is often higher than 43^{0}C and the minimum is a little lower than 18^{0}C.

There are four rainfall seasons in the state viz (i) Winter season (Jan-February), (ii) Hot weather season (March-May), (iii) South-west monsoon (June-September) and (iv) North-east monsoon (October-December).

The annual rainfall of the state is 1020 mm and co-efficient of variation is 20 to 30 per cent increasing from west to east and is about 40 per cent in the extreme south-eastern part. The number of rainy days varies from 53 over the State to less than 40 days in the southwestern part. 75 percent of the area falls in rain shadow region where the annual rainfall ranges from 508 to 1016 mm with an average of 842.2 mm and thus constitutes a semiarid region.

1.6. POPULATION

Total population of Tamil Nadu as per the Census 2001 is given in Table – 1.1.

Table – 1.1 Populations of Tamil Nadu State-Census 2001

	Total Population	Total Male Population	Total Female Population	Total SC Population	Total SC Male Population	Total SC Female Population	Total ST Population	Total ST Male Population	Total ST Female Population
T	62405679	31400909	31004770	11857504	5932925	5924579	651321	328917	322404
R	34921681	17531494	17390187	8308890	4159182	4149708	551143	278746	272397
U	27483998	13869415	13614583	3548614	1773743	1774871	100178	50171	50007

T= Total R= Rural U= Urban SC= Schedule Caste ST= Schedule Tribes

A perusal of the Table – 1.1 reveals that about 44 % of the total population is Urban and the rest is Rural. Male and Female population are more or less equal. Schedule caste and Schedule tribes population constitutes about 19% and 1% of the total population respectively.

1.7. INDUSTRIES

As per data available there are 41,9524 registered small-scale industries in Tamil Nadu. The break-up of these industries in terms of products manufactured is furnished in Table 1.2.

Table – 1.2 Break-up of registered small-scale industries in Tamil Nadu (2001-2002)

Sl. No.	Details of Industry	No. of Units
1	Food Products	38146
2	Beverages and Tobacco products	2779
3	Cotton Textiles	24406
4	Wool Silk Synthetic	2750
5	Jute, Hemp, Rest products	672
6	Hosiery and Readymade Garments	105895
7	Wood and Wood Products	18904
8	Paper and Paper Products	24690
9	Leather Industries	11346
10	Rubber and Plastics	14619
11	Chemical and Chemical Products	18095
12	Non-metallic Mineral Products	12417
13	Basic Metal Products	5861
14	Metal Products	21938
15	Machinery Parts except Electrical	28942
16	Electrical Machinery and apparatus	12271
17	Transport equipments	11827
18	Miscellaneous Manufacturing Industries	63966
20	**TOTAL**	**419524**

(Source: Industries Commissioner and Director of Industries and Commerce, Chennai)

There are 17 Industrial Complexes in Tamil Nadu as on 31.3.2003 developed by Small State Industries Promotion Corporation of Tamil Nadu (SIPCOT). Details of these Industrial Complexes are given in Table – 1.3. The locations of these Industrial Complexes/ Parks/ Growth Centres are shown in Plate – 1.1.

LOCATION OF INDUSTRIAL COMPLEXES/PARKS/GROwTH CENTRES

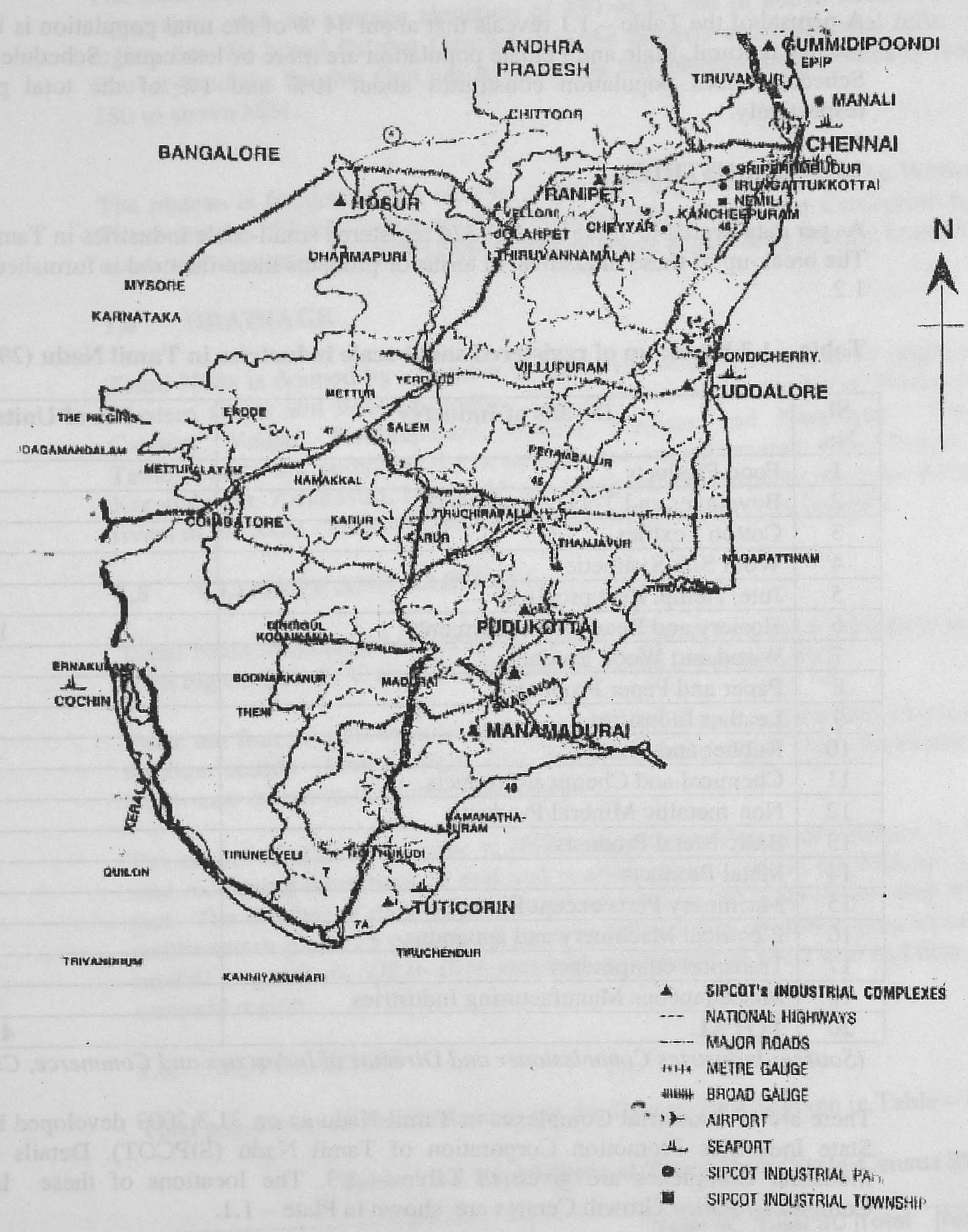


Table – 1.3 Industrial Complexes Developed by SIPCOT in Tamil Nadu as on 31.03.2003 (DOES 2003)

Sl. No.	Name of Industrial Complexes	Area Acquired (Acres)	Year of commencement	No. of units	
				Allotted	Under Implementation
1	Hosur Phase -I	12356.86	1974	184	30
	Hosur Phase -II	456.88	1989	80	25
	Hosur Phase –I Exp. I	179.06	1997	4	1
2	Gummidipoondi Phase - I	780.9	1983	230	2
	Gummidipoondi Phase - II	476.99	1991	6	-
3	EPIP	224.11	1997	1	-
4	Ranipet Phase - I	729.78	1973	114	9
	Ranipet Phase – II	133.13	1983	34	5
	Ranipet Phase - III	496.07	-	-	-
5	Cuddalore Phase -I	518.79	1984	58	4
	Cuddalore Phase -II	154.27	1992	3	3
	Cuddalore Industrial Park	977.78			
6	Pudukkottai	421.1	1980	69	10
7	Manamadurai	492.07	1980	45	6
8	Thoothukudi Phase - I	1083.59		84	23
9	Sriperumpudur	2031.32	1997	12	9
10	Information Technology Park Siruseri	691.76	1998	17	17
11	Gangaikondan	2035.1	1992	4	2
12	Nilakottai	380.16	1992	-	-
13	Perundurai	2599.26	1991	68	46
14	Cheyyar Phase - I	510.97	1995	-	-
15	Barugur	1393	1993	1	-
16	Oragadam	1540.79	1997	-	-
17	Iruganttukottai	1843.68	1996	42	18

(Source: Department of Economic and Statistics, Chennai)

There are different types of industrial activities being carried out by 24,130 working factories in Tamil Nadu. Major industrial activities are grouped and given in Table-1.4.

Table-1.4. Group of Major Industrial Activities

Sl. No.	Description of Industry
1.	Agriculture, hunting and related Service Activities
2	Manufacture of Food Products and Beverages
3	Manufacture of Tobacco Products
4	Manufacture of Textiles
5	Manufacture of Wearing Apparel Dressing and Dyeing of Fur
6	Tanning and Dressing of Leather, Manufacture of Luggage, Handbags, Saddlery, Harness and Footwear
7	Manufacture of Wood and of products of wood and Cork except Furniture, Manufacture of Articles of Straw and Plating Materials
8	Manufacture of paper and paper products
9	Publishing, Printing and Reproduction of Recorded Media
10	Manufacture of Coke, Refined Petroleum Products and Nuclear Fuel
11	Manufacture of Chemical and Chemical Products
12	Manufacture of Rubber and Plastics Products
13	Manufacture of other Non-metallic Mineral Products
14	Manufacture of Basic Metals
15	Manufacture of Fabricated Metal Products except Machinery and Equipments
16	Manufacture of Machinery and Equipment NEC
17	Manufacture of Office, Accounting and Computing Machinery
18	Manufacture of Electrical Machinery and Apparatus NEC
19	Manufacture of Radio, Television and Communication Equipment and Apparatus
20	Manufacture of Medical, Precision and Optical Instruments, Watches and Clocks
21	Manufacture of Motor Vehicles, Trailers and Semi-Trailers
22	Manufacture of Other Transport Equipment
23	Manufacture of Furniture, Manufacturing of NEC
24	Electricity, Gas, Steam and Hot Water supply
25	Collection, Purification and Distribution of Water
26	Sale, Maintenance and Repair of Motor Vehicles and Motor
27	Retail Trade except of Motor Vehicles and Motor Cycles, Repairs of Personal and Household Goods
28	Supporting and Auxiliary Transport activities of Travel agencies
29	Recreational, Cultural and Sporting activities
30	Other Service activities (including Computer and related activities, Sewage and refuse disposal, sanitation and similar activities)

(Source: Dept. of Economics and Statistics, Chennai)

About 30 major activities are being carried out all over Tamil Nadu. However, certain groups of activities are prominent in certain districts only due to various factors, that determine economics of industrial activities such as availability of raw materials, labour, transport, communication and access to shipment/air and other infrastructure facilities. The industries, which are prominent in particular districts are given in Table –1.5.

Table –1.5 District– Wise Major Industrial Activities in Tamil Nadu

Sl. No.	District	Major Industrial Activities
1	Tiruvallur	Petro Chemical based Industries (Manali Area)
2	Kancheepuram	Leather Products (Chrompet Area)
3	Cuddalore	Manufacture of Chemical and Chemical Products (Kudikadu)
4	Dharmapuri	Automobile industries (Hosur)
5	Coimbatore	Manufacture of Textiles
6	Vellore	Tanneries
7	Dindigul	Tanneries
8	Erode	Textile Industries (Dyeing & Bleaching)
9	Trichy	Distilleries, Chemical and Tanneries
10	Salem	Sago Industries
11	Namakkal	Sago Industries
12	Karur	Textile Industries (Dyeing & Bleaching)

Thermal Power Station in Tamil Nadu

1. Ennore Thermal Power Station Tamil Nadu Electricity Board (TNEB), Ennore, Chennai
2. North Madras Thermal Power Station, Tamil Nadu Electricity Board, Chennai
3. Mettur Thermal Power Station TNEB, Mettur Dam, Mettur taluk, Salem district
4. Neyveli Lignite Corporation Ltd., Thermal Power Station- I, Neyveli
5. Neyveli Lignite Corporation Ltd., Thermal Power Station- II (Stage – I), Neyveli
6. Neyveli Lignite Corporation Ltd., Thermal Power Station- II (Stage –II), Neyveli
7. Tuticorin Thermal Power Station, TNEB, Tuticorin.
8. DCW Ltd., Captive Power Plant, Sahupuram – PO, Tuticorin

1.8 PREVIOUS WORK

Systematic Hydrogeological Surveys, aimed at collection of all base level data on occurrence, development and management of ground water resources have been carried out by CGWB in the entire state. District Ground Water Management Studies are also being taken up at regular intervals with a view to update the information collected during systematic surveys and to study the changes in ground water regime due to natural and anthropogenic causes.

Ground water Exploration aided by drilling down to a maximum depth of 300 m bgl in hard rock area and down to a maximum depth of 700 m bgl in sedimentary area has also been carried out in almost entire Tamil Nadu. Ground water regime monitoring is being carried out by measuring water levels in the observation wells established for the purpose four times (January, May, August, November) in a year. Water samples are collected during May every year and analyzed to monitor the quality. In addition to the above Ground Water Pollution studies have been carried out in parts of Tamil Nadu as detailed below in Table – 1.6.

Table – 1.6 Details of Ground Water Pollution studies carried out in Tamil Nadu

Sl,. No.	Area	AAP	Name of Officer
1	Parts of Vellore district (Ranipet-Walajapet Area and Pernambut – Ambur area)	1991-92 & 1992-93	R.Chakrapaani
2	Parts of Dindigul district	1994-95	P.Natarajan
3	Upper Palar basin	1999-2K	D.M.RamaRao
4	Coimbatore district, (Tiruppur Area)	1999-2K	K.Azhahia Nambi
5	Parts of Tiruvallur district (Thangal - Korattur)	2000-01	K.Shivashanmuganathan
6	Parts of Tiruvallur district (Manali Industrial area)	2001-02	B.Umapathi
7	Parts of Tiruvallur district (Ambattur Industrial area)	2002-03	K.A.Nambi
8	Parts of Dindigul district	Under H.P.	E.Sampathkumar

1.9 IMPACT OF DEVELOPMENT ON GROUND WATER

The ever-decreasing trend in the area covered by forests is significant in the country and Tamil Nadu State is no exception. The felling of trees and appropriation of forest lands, irrigation tanks, ponds, river courses and other open lands have added up to the already existing hazards like changes in climate, failing rains, soil erosion and declining ground water recharge conditions. The continual decline of water table is noticed in many parts of the State leading to drying up of a number of ground water abstraction structures. The depth to water level has gone below 40 m in parts of Salem, Coimbatore, Erode and Madurai districts and centrifugal pumps are no more in use. The extra head in lift has resulted in increased energy consumption. The development of deeper fractures have resulted in mushrooming growth of bore wells and air-compressor motors, in parts of Salem, Coimbatore, Erode and Dharmapuri districts thereby lowering water table / pressure head down to as much as 120 m as in Rasipuram taluk of Salem district.

The excessive stress on water resources development in certain areas has critically damaged the environment. Incidence of heavy rainfall experienced in recent times has failed to replenish the ground water storage to the post monsoon levels of 1970. Many dug wells remaining dry for years have become garbage bins and add to the pollution hazards. The industrial pollution of air and water has affected the drinking water sources and certain agricultural lands. Urbanization has progressed at the cost of agriculture and natural environment. The filling up of tanks and their development as residential complexes are on the increase, thereby affecting the recharge conditions. The benefits envisaged from water management schemes and other recharge measures like percolation ponds are negated on many cases due to the encroachment of stream beds for agriculture and conversion of agricultural land to residential plots.

Chapter – 2

GROUND WATER CONDITIONS IN TAMIL NADU

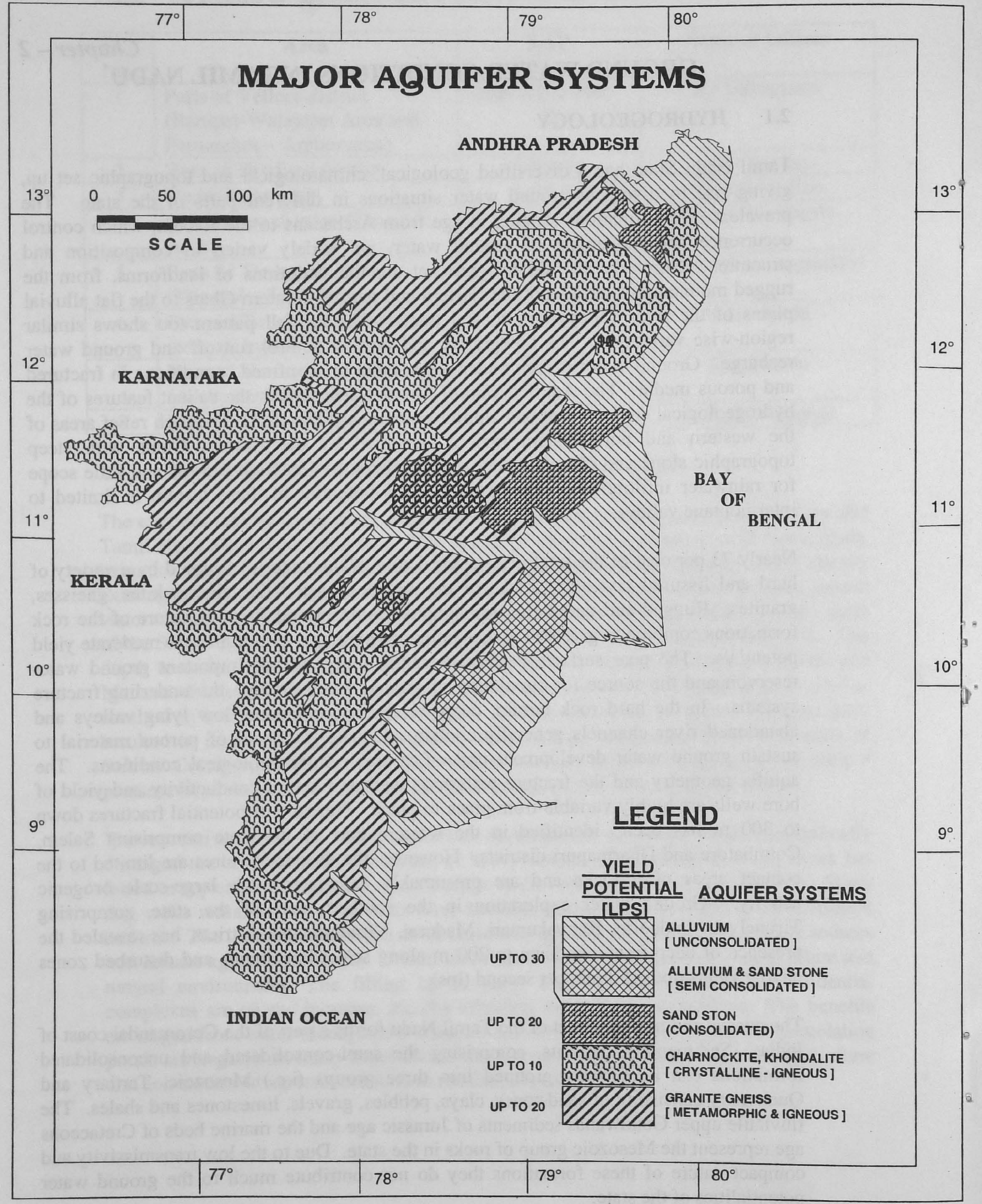
2.1 HYDROGEOLOGY

Tamil Nadu State has a diversified geological, climatological and topographic set up, giving rise to divergent ground water situations in different parts of the state. The prevalent rock formations ranging in age from Archaeans to the Recent, which control occurrence and movement of ground water, are widely varied in composition and structure. Similarly not too insignificant are the variations of landforms, from the rugged mountainous terrains of the Eastern and part of Western Ghats to the flat alluvial plains of the river valleys and coastal tracts. The rainfall pattern too shows similar region-wise variations. The topography and rainfall control run off and ground water recharge. Ground water occurs under water table to confined conditions in fractured and porous media. The Aquifer Map of Tamil Nadu depicts the salient features of the hydrogeological environment and aquifer potentials (Plate-2.1). The high relief areas of the western and northwestern regions occupied by the Eastern Ghats with steep topographic slope and characteristic geological setup offer high run-off and little scope for rainwater infiltrations. The ground water potential in these terrain is limited to intermontane valleys.

Nearly 73 per cent of the total geographical area of the state is occupied by a variety of hard and fissured crystalline rocks of the Archaean age VIZ., charnockites, gneisses, granites. Rugged and undulating topography, compact and fissured nature of the rock formations combine to give rise to discontinuous aquifers, with limited to moderate yield potentials. The near surface weathered mantle forms the all important ground water reservoir and the source for circulation of ground water through the underling fracture systems. In the hard rock terrain, deep weathered pediments, low lying valleys and abandoned river channels generally contain adequate thickness of porous material to sustain ground water development under favourable hydrogeological conditions. The aquifer geometry and the fracture pattern as well as fracture conductivity and yield of bore wells are highly variable from place to place. Presence of potential fractures down to 300 m has been identified in the western part of the state comprising Salem, Coimbatore and Dharmapuri districts. However, the deeper fractures are limited to the contact areas of hillocks and are presumably associated with large-scale orogenic activity. Ground water exploration in the southern part of the state, comprising Tirunelveli, Tuticorin, Kanyakumari, Madurai, Virudhunagar districts, has revealed the presence of deep fractures down to 200 m along select lineaments and disturbed zones having yields upto 15 liters per second (lps).

The coastal sedimentary tract of the Tamil Nadu forms a part of the Coromandal coast of India. Sedimentary deposits, comprising the semi-consolidated and unconsolidated formations can be broadly grouped into three groups (i.e.) Mesozoic, Tertiary and Quaternary consisting of sandstones, clays, pebbles, gravels, limestones and shales. The fluviatile upper Gondwanas sediments of Jurassic age and the marine beds of Cretaceous age represent the Mesozoic group of rocks in the state. Due to the low transmissivity and compact nature of these formations they do not contribute much to the ground water potentialities of the state.

PLATE - 2.1



MAJOR AQUIFER SYSTEMS

Tertiary formations consisting of porous and permeable Cuddalore sandstones are the most potential sources of ground water in the state. The aquifers in these formations are highly productive and ground water generally occurs under confined conditions. Depending upon the topography and thickness of overburden, the piezometric heads vary widely. Auto flowing zones are not uncommon in these formations.

Quaternary sediments in the state are represented by laterite, older alluvium of Pleistocene age and Recent alluvium, 'Teris' and coastal sands. The eastern coastal and deltaic tracts of the state are the receptacles of thick alluvial sediments. Major rivers such as Palar, Ponnaiyar, Cauvery and Vaigai have deposited rich alluvium in their deltaic regions. Cauvery alluvium, occupying a major part of the Thanjavur district includes potential alluvial aquifers. Other important alluvial aquifers occur in Kancheepuram, Tiruvallur, Vellore, Pudukottai and Ramanathapuram districts.

Though highly productive aquifers occur in these tracts, salinity hazards impose quality constraints for ground water development. In this terrain, the ground water withdrawal requires to be regulated so as not to exceed annual recharge and not to disturb hydrochemical balance leading to seawater ingress. But in some cases, excess withdrawal of ground water to the industrial and urban domestic requirement, seawater ingress has already occurred e.g., North Chennai – Minjur area.

The varied modes of ground water occurrence in the state may be broadly summarised as:

(a) Consolidated and fissured formations – Aquifers are heterogenous and discontinuous with limited yield potentials.
(b) Porous formations comprising unconsolidated and semi-consolidated sediments. Aquifers homogenous, inter-connected, often extensive, both continuous and discontinuous, moderate to very high yield potentials.

The distribution and potential of the major hydrogeological units are presented in Table – 2.1.

Table – 2.1 Distributions and Potential of Major Hydrogeological Units (CGWB 1996 B)

Geological Age	Rock Formation	Districts/Hydrogeological Characters.
Unconsolidated formations Recent	*Soils, Beach sands Alluvium (newer)- sands, clays, gravels, silt & calcareous concretions*	*Occur in the eastern part of the coastal districts of Tamil Nadu. Laterite capping is exposed in the high altitudes of Palani, Nilgiris, Shevaroy and Kolli hills. Patches of laterite are seen at the contact of upper Gondwana and Cretaceous formations in Trichirapalli, Tuticorin and Ramanathapuram districts. Recent wind blown sands (Teri sands) are seen in Ramanathapuram and Tuticorin districts. Recent alluvium comprising clay, sand, gravel and pebble are seen in the river valleys of deltaic regions and coastal plains. Older alluvium is relatively compact.*

Geological Age	Rock Formation	Districts/Hydrogeological Characters.
Pleistocene	*Boulder Conglomerates Alluvium (older_, sands, clays & laterite.*	*The alluvia of the major rivers comprising a thick sequence of sand form potential aquifers. The Cauvery alluvium occupying a major part of Thanjavur dist. has potential alluvial aquifers. Other important alluvial aquifers occur in Kancheepuram, Vellore, Pudukottai, Ramanathapuram and Madurai districts. The aquifers are of highly variable nature in thickness from place to place. Ground water occurs under both water table and confined conditions. Important and potential granular zones occur between the depth ranges of 7 to 70 m.bgl. The yield depends on the potentiality of the aquifer and in general, ranges from 15 to 50 M/hr.. The transmissivity of the aquifer varies from 4,800-10,000 M/day. Ground Water potential is limited by salinity hazards*
Semi consolidated Formations Tertiary	*Karaikal Beds-Sands and clays with fossils* *Cuddalore sand stones-Mottled & friable sand stones, buff colored clays & gravel.* *Cretaceous-Arenaceous limestones & sandstones, clays shell limestones Basal limestones & Coral rags.*	*Sandstones of Upper Cretaceous occur in Vanur area of Cuddalore & Ariyalur area of Perambalur districts and possess promising granular zones worthy of ground water development. Ground water occurs both under water table & confined conditions. The yields of the shallow tube wells are moderate (25 m to 40m^3/hr for a draw down of 5 to 8m). The transmissivity & permeability of the aquifers of the Vanur sandstones vary from 1.6 to 829 m^2/d & 0.038 to 12.6 m/d respectively. Yields of tube wells with depths ranging from 60 to 180m. near Ariyalur, Perambalur district vary between 45 & 65m^3/hr for draw downs of 2 to 3 m.* *Tertiary formations are potential source of ground water in the State. The Cuddalore Sandstones of Miocene age contain highly permeable aquifers. Primary porosity and hydraulic conductivity are moderate to high. Ground water generally occurs under confined conditions. It is under high pressure and Free flowing conditions occur notably in Cuddalore district, Cauvery delta of Tanjore district eastern part of Pudukottai district and northeastern part of Ramanathapuram district with free flow of upto 4.5 m^3/min. (270 m^3/hr). Water levels of wells tapping non-flowing confined aquifers vary widely depending upon the topography, thickness of over burden and piezometric head difference. In general they range up to 44 m.bgl and at places are as deep as 53 m bgl. The discharges vary from 27 to 212 m^3/hr. The transmissivity varies between 150 to 4000 m^2/day. The storativity ranges from 0.000005 to 0.00055. The ground water in Cuddalore sandstones in the eastern part of the coastal tract of Thanjavur Pudukottai and Ramanathapuram districts are generally saline.*

2.2 GROUND WATER REGIME

The behavior of ground water table during the ground water year 2002-2003 in Tamil Nadu state has been studied by monitoring of observation wells during May 2002, August 2002, November 2002 and January 2003. In the last measurement during January 2003 in the ground water year 2002-03, monitoring was carried out in both phreatic and confined aquifers through 650 dug wells, 56 tube wells 152 piezometers. The data on water levels and peizometric surface were analyzed in detail and salient features as follow:

The rainfall during northeast monsoon was deficient over major part of the state. During transitional period and southwest monsoon period rainfall was deficient in the coastal part and normal over rest of the state.

In May 2002, the depth to water level ranged from 0.1 (Tiruvarur district) to 48.31 m bgl (Cuddalore district) in Tamil Nadu. Depth to water level over major part of the state was within 10 m bgl (about 71% of wells). The depth to piezometric surface ranged from 0.62 (Cuddalore district) to 47.88 m bgl (Cuddalore district). The depth to piezometric surface within 10 m bgl is noticed in 39% of the wells analyzed.

In August 2002, the depth to water level ranged from 0.4 (Dharmapuri district) to 44.98 m bgl (Villupuram district) in Tamil Nadu and depth to water level was within 10 m bgl, in nearly 62% of wells analyzed. The depth to piezometric surface ranged from 1.34 (Nagapattinam district) to 51.98 m bgl (Coimbatore district). The depth to piezometric surface within 10 m bgl was observed in 28% of the wells analyzed.

In November 2002, the depth to water level ranged from 0.09 (Chennai district) to 52.86 m bgl (Coimbatore district) in Tamil Nadu and within 10 m bgl, in nearly 75% of wells analyzed. The depth to peizometric surface ranged from 0.91 (Dharmapuri district) to 99.4 m bgl (Cuddalore district). The depth to peizometric surface within 10 m bgl was observed in 40% of the wells analyzed.

In January 2003, the depth to water level ranged from 0.1 (Perambalur district) to 54.14 m bgl (Coimbatore district) in Tamil Nadu and was within 10 m bgl in nearly 77% of wells analyzed. The depth to peizometric surface ranged from 0.15 (Nagapattinam district) to 57.96 m bgl (Coimbatore district). The depth to peizometric surface was within 10 m bgl in about 38% of the wells analyzed.

2.3 QUALITY OF GROUND WATER

The quality of ground water in the state varies from place to place depending on the lithology, climatic conditions, rainfall and topography. In the hard rock terrain ground water is generally potable and suitable for all uses. There are however some patches of alkaline and brackish water. In the cases of sedimentaries, the quality of water varies from potable to saline and the aquifer system shows wide quality variations in both lateral and vertical. Changes in water type from bicarbonate to chloride towards coast are common. The coastal aquifers, at places, have seawater intrusion problems. Marine transgressions in the geologic part and regression have resulted in varied degree of mineralization in ground water.

In addition, the fluoride content in the formation waters in many wells in northwestern and western parts of the state comprising the districts of Dharmapuri, Salem, Coimbatore, Erode and Trichy is excess over the permissible limit (i.e) 1.5 ppm.

There are also pockets in different parts of the state where ground water has been highly polluted due to the indiscriminate discharge of untreated industrial effluents as noticed in parts of Chennai, Vellore, Dindigul, Coimbatore, Erode and Salem districts.

The quality of shallow ground water in Tamil Nadu and U.T. of Pondicherry is evaluated by the sampling and analysis of water samples collected from the Network Hydrograph Stations. The range of chemical constituents given in Table-2.2.

Electrical Conductivity

About 16% of the wells analysed show EC <750 μS/cm and are noticed as small patches in parts of Tiruvallur, Kancheepuram, Villupuram, Cuddalore, Nagapattinam, Tiruvarur, Thanjavur, Pudukkottai, Sivaganga, Ramanathapuram, Tuticorin, Tirunelveli, Madurai and Dharmapuri districts. 35% of wells analysed show EC value between 750 to 1500 μS/cm and are noticed in major part of the state. EC value of 1500 to 2250 μS/cm is noticed in 19% of the wells analysed and are noticed mainly in central part of the state and as small pockets in most of the districts. EC value of > 2250 μS/cm is noticed in 29% of the wells analysed and are noticed predominantly in coastal areas falling in Tiruvallur, Kancheepuram, Nagapattinam, Pudukkottai, Ramanathapuram, Tuticorin district and in inland areas falling in Madurai, Virudhunagar, Sivaganga, Coimbatore, Namakkal, Salem, Dharmapuri, Vellore and Tiruvannamalai districts.

Distribution of Chloride

About 56% of the wells analysed show Chloride <250 mg/lit. and are noticed in major part of the State. 22% of wells analysed show Chloride value between 250 to 500 mg/lit. and are noticed as small patches in most of the districts. Chloride value of 500 to 1000 mkg/lit. is noticed in 14% of the wells analysed and is noticed as small patches in Tiruvallur, Kancheepuram, Villupuram, Cuddalore, Nagapattinam, Thanjavur, Tiruvarur, Pudukkottai, Ramanathapuram, Tuticorin, Tirunelveli, Virudhunagar, Dindigul, Coimbatore, Erode, Namakkal, Dharmapuri and Vellore districts. Chloride value of >1000 mg/lit is noticed in 7% of the wells analysed and are noticed predominantly in coastal areas falling in Kancheepuram, Thanjavur, Pudukkottai, Sivaganga, Ramanathapuram, Tuticorin districts and in inland areas falling in Madurai, Virudhunagar, Sivaganga, Coimbatore, Salem and Vellore districts.

Table 2.2 Range of chemical constituents

S.No.	Chemical Constituent	Min.	Max.
1	pH	6.10	8.66
2	EC	30.00	40,100
3	TH	20.00	7,300
4	Ca	2.00	480
5	Mg	1.00	422
6	Na	0.7	8650
7	HCO_3	18.0	1013
8	CO_3	0	99
9	SO_4	0.3	2000
10	Cl	3.5	15265
11	NO_3	0.0	644
12	F	0.0	3.1

Distribution of Nitrate

About 59% of the wells analysed show Nitrate <45 mg/lit. while 15% of wells analysed show Nitrate value in the range of 45 to 90 mg/lit. 16% of the wells show Nitrate concentration in the range of 90 to 180 mg/lit and 9% show Nitrate value more than 180 mg/lit.

Distribution of Fluoride

About 64% of the wells analysed show Fluoride <1 mg/lit and are noticed in major part of the State. 29% of wells analysed show Fluoride value between 1 to 2 mg/lit, while 7% show Fluoride value in the range of 2 to 3 mg/lit and 0.3% show more than 3 mg/lit.

The major part of the state shows Fluoride within the prescribed limit of 1.5 mg/lit. concentration higher than the permissible limits are noticed as small patches in Pudukkottai, Theni, Dindigul, Coimbatore, Erode, Namakkal, Salem and Dharmapuri districts.

2.4 GROUND WATER DEVELOPMENT

A few decades ago, ground water development in Tamil Nadu was generally restricted to the shallow zones within 50 m depth and was mostly financed through institutional sources and private efforts. The shallow ground water structures; include dug wells, dug-cum-bore wells, shallow tube wells, filter points etc. The deeper structures include heavy-duty tube wells and bore wells. The development of the deeper zone (50 to 300 m bgl) was usually in Government / Public sector for the drinking water supply schemes and also for irrigation. The ground water extraction has increased many fold, resulting in progressive decline in water level and drying up of shallow wells. With the advent of new technology, farmers have started drilling bore wells down to 300 m bgl and even more and are using submersible pumps and compressors. Bore/tube wells have now become the most common ground water abstraction structures especially for irrigation and industrial uses in many districts like Salem, Erode, Coimbatore etc

The ground water development has been intensive in the alluvial areas of the major rivers namely Cauvery, Palar and Vaigai and also in parts of hard rock terrains especially in the western parts of the state. In localized pockets in these areas, decline of water levels up to 10 m or more has been noticed.

Chapter-3

WATER QUALITY CRITERIA

The available quality of ground water is the resultant of all the processes and reactions which has taken place since the condensation of water in the atmosphere to the time it is retrieved in the form of ground water from its source. The water has excellent capability to accumulate substances in soluble form as it moves from the biological processes and from human activities. Urbanization, agricultural development and discharges of municipal and industrial residues significantly alter characteristics of ground water resource. The prevailing climatic conditions, topography, geological formations and use and abuse of this vital resource have significant affect on the characteristics of the water, because of which its quality varies with locations.

The definition of criteria and standards for water quality vary with the type of use. The characteristic of water required for human consumption, livestock, irrigation and industries have different water quality requirements.

The term water quality criteria may be defined as the " Scientific data evaluated to derive recommendations for characteristics of water for specific use ". The term ' standard' applies to any definite rule, principle or measure established by any statutory Authority. The distinction between criteria and standards is important, as the two are neither interchangeable nor they become synonyms for the objective or goal. Realistic standards are dependent on criteria, designated uses and implementation as well as identification and monitoring procedure. The changes in all these factors may provide a basis for alteration in standards.

In formulation of water quality criteria, the selection of water quality parameters depends on its and use (Sayers et.al. 1976 as quoted in CGWB & CPCB 2000) identified the key water quality parameters according to its various uses (Table- 3.1).

Table- 3.1 Water quality criteria parameters for various uses (Sayers et.al., 1976 as quoted in CGWB & CPCB 2000)

Public Water supply	Industrial Water supply	Agricultural water supply	Aquatic life & wild life water supply	Recreation and Aesthetics	Fish & aquatic supply
Coliform bacteria Turbidity colour, Taste Odour TDS, CI, F, SO_4 NO_3, CN, Trace Metals Trace Organics Radioactive substances	Processing PH, Turbidity Colour, Alkalinity, Acidity, TDS, Suspended solids, Trace metals, Trace Organics Cooling PH, Temp, silica, AI, Fe, Mg, Total hardness, Alkalinity / Acidity suspended solids, Salinity	Farm Stead Same as for public supply Live-stock Same as for public supply Irrigation TDS, EC, Na, Ca, Mg, K, B, CI and Trace metals	Temp, DO, pH, Alkalinity, Acidity, TDS Salinity, pH, DCOs, Turbidity colour, Settleable material, Toxic substances, Nutrients, Floating material	Recreations Tem, Turbidity, colour Odour, Floating Material, Settable Material Nutrients, Coliforms Aesthetics Temp, Turbidity, Colour, Odour, Floating Material, settelable material, nutrients and Substances adversely affecting wild life	

3.1 WATER QUALITY CRITERIA FOR DRINKING PURPOSE.

With the objective of safeguarding water from degradation and to establish a basis for improvement in water quality, standards / guide lines / regulations have been laid down by various national and international Organisations such as; Bureau of Indian Standards (BIS), World Health Organisation (WHO), European Economic Community (EEC), Environmental Protection Agency (EPA), United States, and Inland Waters Directorate, Canada. The Bureau of Indian Standards (BIS) earlier known as Indian Standards Institutions (ISI) has laid down the standard specification for drinking water during 1983, which have been revised and updated from time to time. In order to enable the users, to exercise their discretion towards water quality criteria, the maximum permissible limit has been prescribed especially where no alternative sources are available. The national water quality standards describe essential and desirable characteristics required to be evaluated to assess suitability of water for drinking purposes. The important water quality characteristics as laid down in BIS standard (IS-10500, 1991) are summarized in Table-3.2.

Table - 3.2 Drinking water characteristics

Sl. No	Parameters	Desirable Limits (mg/l)	Permissible limits (mg/l)
Essential Characteristics			
1	*Colour Hazen Unit*	*5*	*25*
2	*Odour*	*Unobjectionable*	-
3	*Taste*	*Agreeable*	-
4	*Turbidity (NTU+)*	*5*	*10*
5	*pH*	*6.5-8.5*	*No relaxation*
6	*Total Hardness, $CaCO_3$*	*300*	*600*
7	*Iron (Fe)*	*0.3*	*1.0*
8	*Chloride (Cl)*	*250*	*1000*
9	*Residual Free Chlorine*	*0.2*	-
10	*Fluoride (F)*	*1.0*	*1.5*
Desirable Characteristics			
11	*Dissolved Solids*	*500*	*2000*
12	*Calcium (Ca)*	*75*	*200*
13	*Magnesium (Mg)*	*30*	*100*
14	*Copper (Cu)*	*0.05*	*1.5*
15	*Manganese (Mn)*	*0.1*	*0.3*
16	*Sulphate (SO_4)*	*200*	*400*
17	*Nitrate (NO_3)*	*45*	*100*
18	*Phenolic Compounds*	*0.001*	*0.002*
19	*Mercury (Hg)*	*0.001*	*No relaxation*
20	*Cadmium (Cd)*	*0.01*	*No relaxation*
21	*Selenium (Se)*	*0.01*	*No relaxation*
22	*Arsenic (As)*	*0.05*	*No relaxation*
23	*Cyanide (CN)*	*0.05*	*No relaxation*
24	*Lead (Pb)*	*0.05*	*No relaxation*
25	*Zinc (Zn)*	*5.0*	*15*
26	*Hexavelant Chromium*	*0.05*	*No relaxation*
27	*Alkalinity*	*200*	*600*
28	*Aluminium (Al)*	*0.03*	*0.2*
29	*Boron (B)*	*1.0*	*5.0*
30	*Pesticides*	*Absent*	*0.001*

NTU- Nephelometric Turbidity Unit.

N.B. The fluoride limits vary with average annual temperature of the areas. Similarly the limits for magnesium are based on sulphate contents of water. When sulphate content is 250 ppm or above, the magnesium should be between 30 to 50 ppm but if sulphate is lower, higher content of magnesium is permissible.

3.1.1. Bacteriological Standards.

The coliform group of bacteria is the principal indicator of suitability of a water for domestic, industrial or other uses. The density of coliform group of bacteria is the criterion for the degree of contamination and has been the basis for bacteriological water quality standards. In an ideal situation, all the samples taken from the distribution system should be free from coliform organisms but in practice it is not attainable always and therefore the following standards for water has been recommended by Bureau of Indian standard (IS-10500, 1991).

i) 95 percent of water samples should not contain any coliform organisms in 100 ml throughout the year.
ii) No water sample should contain E.Coil in 100 ml water.
iii) No water sample should contain more than 10 coliform organisms per 100 ml.
iv) Coliform organisms should not be detectable in 100 ml of any two consecutive water samples.

However, from bacteriological considerations, the objective should be to reduce the coliform count to less than 10 per 100 ml and more importantly the absence of faecal coliforms should be ensured. The international norms of water quality for drinking have been established by World Health Organization (WHO), 1996, as Guidelines for drinking water quality with regard to inorganic constituents, organic matter and bacteriological characteristics (Table-3.3 & 3.4).

Table - 3.3 Organic constituents of health significance, Pesticides (World Health Organization, 1996)

S. No	Organic constituents	Guideline Value (mg/l)	Remarks
1	*Alachlor*	*20*	*For excess risk of 10*
2	*Aldicarb*	*10*	
3	*Aldrin/dieldrin*	*0.03*	
4	*Atrazine*	*2*	
5	*Bentazone*	*30*	
6	*Carbofuran*	*5*	
7	*Chlordane*	*0.2*	
8	*Chlorotoluron*	*30*	
9	*DDT*	*2*	
10	*1,2-dibromo-3-chloropropane*	*1*	*For excess risk of* 10^5
11	*2,4-D*	*30*	
12	*1,2-dichloropropane*	*20(P)*	
13	*1,3- dichloropropane*	-	*NAD*
14	*1,3- dichloropropane*	*20*	*For excess off* 10^5
15	*Ethylene dibromide*	-	*NAD*
16	*Heptachlor and Heptachlor epoaxide*	*0.03*	

S. No	Organic constituents	Guideline Value (mg/l)	Remarks
17	*Hexachlorobenzene*	*1*	*For excess risk of* 10^{5}
18	*Isoproturon*	*9*	
19	*Lindane*	*2*	
20	*MCPA*	*2*	
21	*Methoxychlor*	*20*	
22	*Metolachlor*	*10*	
23	*Molinate*	*6*	
24	*Pendimathalin*	*20*	
25	*Pentachlorophenol*	*9(P)*	
26	*Permethrin*	*20*	
27	*Propanil*	*20*	
28	*Pyridate*	*100*	
29	*Simazine*	*2*	
30	*Trifluralin*	*20*	
31	*Chlorophenoxy herbicides 2,4-DB Other than 2,4-D and MCPA*	*90*	
32	*Dichlorprop*	*100*	
33	*Fenoprop*	*9*	
34	*MCPB*	-	*NAD*
35	*Mecoprop*	*10*	
36	*2,4,5-T*	*9*	

P — Provisional guideline.
NAD -- No adequate data to permit recommendation.

Table - 3.4 Bacteriological quality of drinking water (World Health Organization, 1996)

Organisms	Guideline Value
All water intended for drinking	
E.Coil or thermo-tolerant coliform bacteria	*Must not be detectable in any 100/ml sample*
Treated water entering the distribution system	
E.Coil or thermo-tolerant coliform bacteria	*Must not be detectable in any 100/ml sample*
Total coliform bacteria	*Must not be detectable in any 100/ml sample*
Treated water in the distribution system	
E.Coil or thermo-tolerant coliform bacteria	*Must not be detectable in any 100/ml sample*
Total coliform bacteria	*Must not be detectable in any 100/ml sample. In the case of large supplies. Where sufficient samples are examined must not be present in 95% of sample taken throughout any 12-month period.*

Immediate investigative action must be taken if either E.Coil or total coliform bacteria are detected. The minimum action in the case of Total coliform bacteria is repeat sampling. If these bacteria are detected in the repeat sample, the cause must be determined by immediate further investigation.

Although E.Coil is and the most precise indicator of faecal pollution, the count of thermo-tolerant, coliform bacteria is an acceptable alternative. If necessary, proper confirmatory tests must be carried out. Total coliform bacteria are not acceptable indicators of the sanitary quality of the water supplies, particularly in tropical areas where many bacteria of no sanitary significance occur in almost all untreated supplies.

It is recognized that in the great majority of rural water supplies in developing countries, faecal contamination is widespread. Under these conditions, the national surveillance agency should set medium-term targets for the progressive improvement of water supplies.

3.2 WATER QUALITY CRITERIA FOR IRRIGATION PURPOSE.

Water quality plays a significant role in irrigated agriculture. Many problems originate due to inefficient management of water for agriculture use, especially when it carries high salt loads. The effect of total dissolved salts in irrigation water (measured in terms of electrical conductance) on crop growth is extremely important. Soil water passes into the plant through the root zone due to osmotic pressure and the plants root membrane are able to assimilate water and nutrients. Thus, the dissolved solid contents of the residual water in the root zone also have to be maintained within limits by proper leaching. These effects are visible in plants by their stunted growth, low yield, discoloration and even leaf burns at margin or top. The safe limits of electrical conductivity for crops of different degrees of salt tolerances under varying soil textures and drainage conditions are presented in Table-3.5.

Table - 3.5 Safe Limits for electrical conductivity for irrigation water (As quoted in CGWB & CPCB 2000)

S. No	Nature of soil	Crop growth	Upper permissible safe limit of electrical conductivity in water (µs/cm at 25°C)
1	*Deep black soil and alluvial soils having clay content more than 30%; soils that are fairly to moderately well drained*	*Semi-tolerant*	*1500*
		Tolerant	*2000*
2	*Textured soils having clay contents of 20-30% ; soils that are well drained internally and have good surface drainage system*	*Semi-tolerant*	*2000*
		Tolerant	*4000*
3	*Medium textured soils having clay 10-20%; internally very well drained and having good surface drainage system*	*Semi-tolerant*	*4000*
		Tolerant	*6000*
4	*Light textured soils having clay less than 10% ; soils that have excellent internal and surface drainage system.*	*Semi-tolerant*	*6000*
		Tolerant	*8000*

In addition to problems caused by total amount of salts, some of the specific ions like sodium, boron and trace elements, if present in water in excess, also render it unsuitable for agricultural use.

3.2.1 Sodium

The clay minerals in the soil adsorb divalent cations like calcium and magnesium ions from irrigation water. Whenever the exchange sites in clay are filled by divalent cations, the soil texture is conducive for plant growth. Sodium reacts with soil to reduce its permeability. In case the irrigation water is sodium dominant, the clay lattice is filled with sodium ions due to ion exchange. Such soils become impermeable and sticky and as such the cultivation becomes difficult to support plant growth. However, the cation exchange process is reversible and can be controlled either by adjusting the composition of water or by soil amendment by application of gypsum, which releases cations (Calcium) to occupy the exchange position. The tendency of water to replace absorbed calcium and magnesium with sodium can be expressed by the Sodium Adsorption Ratio (SAR), where all the ion concentration/s are in milli-equivalents per litre (meq/l).

$$SAR = (Na^+)$$

When water having high bicarbonates and low calcium and magnesium is used for irrigation purpose, precipitation of calcium and magnesium as carbonate takes place, changing the residual water to high sodium water with sodium bicarbonate in solution. It is termed as Residual Sodium Carbonate (RSC) which is expressed as

$$RSC\ (meq/l) = (CO_3\ \ HCO_3) - (Ca\ \ Mg)$$

(Where all the ions concentrations are in milli equivalents / litre)

The quality of water is commonly expressed by classes of relative suitability for irrigation with reference to salinity levels. The recommended declassification with respect to Electrical Conductivity, Sodium content, Sodium Absorption Ratio, and Residual Sodium Carbonate, under customary irrigation conditions has been depicted in Table-3.6.

Table - 3.7 Guidelines for evaluation of quality of irrigation water

Water class	Sodium (Na) %	Electrical conductivity (µs/cm at 25°C)	Alkalinity hazards	
			SAR	RSC (meq/l)
Excellent	*< 20*	*< 250*	*< 10*	*< 1.25*
Good	*20 – 40*	*250 –750*	*10 – 18*	*1.25 – 2.0*
Medium	*40 – 60*	*750 – 2250*	*18 – 26*	*2.0 – 2.5*
Bad	*60 –80*	*2250 – 4000*	*> 26*	*2.5 – 3.0*
Very bad	*> 80*	*> 4000*	*> 26*	*> 3.0*

3.2.2 Boron

Boron is essential for plant nutrition and is sometimes added to fertilizers in small amounts to make up for the boron deficiency particularly in humid regions. However, excess of boron over the required amount is toxic to certain plants. The irrigation water rating based on boron is presented in Table-3.7 for sensitive, semi-tolerant and tolerant crops.

Table - 3.7 Rating of irrigation water based on Boron concentration in the water, (U.S.Salinity Laboratory Staff)

Class of water	Boron concentration (mg/l)		
	Sensitive crops	**Semitolerant crops**	**Tolerant crops**
Excellent	*< 0.33*	*< 0.67*	*< 1.00*
Good	*0.33 – 0.67*	*0.67 – 1.33*	*1.00 – 2.00*
Permissible	*0.67 – 1.00*	*1.33 – 2.00*	*2.00 – 3.00*
Doubtful	*1.00 – 1.25*	*2.00 – 2.50*	*3.00 – 3.75*
Unsuitable	*> 1.25*	*> 2.50*	*> 3.75*

3.2.3 Trace Elements

There are certain specific trace elements, which have varying effects on plant growth. These trace elements include those occurring naturally in irrigation water, those introduced by man's activities and those, which enter the soil through interaction between the soil and irrigation water. Some of these elements are essential for plant growth, others may be non-essential, and sometimes harmful. The tolerance limit of trace elements in irrigation waters are presented in Table-3.8.

Table 3.8 Trace elements tolerance for irrigation waters (Environment Studies Board, 1973)

Trace element	Trace element tolerance limit (mg/l)	
	Acid soils or all soils in continuous use	**Find textured Alkaline soils**
Aluminium	*5.00*	*20.00*
Arsenic	*0.10*	*2.00*
Beryllium	*0.10*	*0.50*
Boron	*0.50*	*1.00*
Cadmium	*0.01*	*0.05*
Chromium	*0.10*	*1.00*
Cobalt	*0.05*	*5.00*
Copper	*0.20*	*5.00*
Iron	*5.00*	*20.00*
Lead	*5.00*	*10.00*
Lithium	*2.50*	*2.50*
Manganese	*0.20*	*10.00*
Molybdenum	*0.01*	*0.01*
Nickel	*0.20*	*2.00*
Vanadium	*0.10*	*1.00*
Zinc	*2.00*	*10.00*

3.3 WATER QUALITY CRITERIA FOR INDUSTRIAL PURPOSE

The demands of water for industrial use are increasing more rapidly and the magnitude of the industrial demand demonstrates the extreme importance of water to the industry. Water is used for industrial purposes as an ingredient with other raw materials in the finished product, as a buoyant transporting medium, as a cleansing agent, as a coolant, as a source of steam in heating and power production etc.

The quality requirements for water in the industry vary with its use. The industrial use of water may have several functions / processes and water of different specifications or quality would be required for washing purposes, for cooling purposes and for manufacturing processes.

Water quality may affect the product (decay resulting from biological activity, staining, corrosion, chemical reaction and contaminations), deteriorate the equipment (corrosion, erosion, cavitation, scale formation etc.) and may reduce the efficiency of the equipment (tuberculation, sludge formation, foaming and organic growth etc.)

It is difficult to organize the quality requirements / criteria of the water used in various industrial processes into a single set of standards. However, the threshold values and recommended water quality requirement for some common and prominent industries are summarised in Table-3.9.

Table 3.9 Water-quality requirement for selected industries and process

Constituent (mg/l)	Textile scouring bleaching & dyeing	Chemical pulp and paper		Wood chemical	Synthetic rubber	Petroleum products	Canned, dried frozen fruits & vegetables	Soft drinks bottling	Leather tanning, general finishing processes	Hydraulic cement manufacture
		Unbleached	Bleached							
Silica (SiO_2)	-	50	50	50	-	-	50	-	-	35
Iron (*Fe*)	0.1	1.0	0.1	0.3	0.1	1.0	0.2	0.3	0.3	25
Manganese (*Mn*)	0.01	0.5	0.05	0.2	0.1	-	0.2	0.05	0.2	0.5
Calcium (*Ca*)	-	20	20	100	80	75	-	100	-	-
Magnesium (*Mg*)	-	12	12	50	36	30	-	-	-	-
Copper (*Cu*)	0.01	-	-	-	-	-	-	-	-	-
Bi-carbonate (HCO_3)	-	-	-	250	-	-	-	-	-	-
Sulphate (SO_4)	-	-	-	100	-	-	250	500	250	250
Chloride (*Cl*)	-	200	200	500	-	300	250	500	250	250
Fluoride (*F*)	-	-	-	-	-	-	1.0	(1)	-	-
Nitrate (NO_3)	-	-	-	5	-	-	10.0	-	-	-
Hardness as $CaCO_3$	25.0	100	100	900	350	350	250	-	-	-

Constituent (mg/l)	Textile scouring bleaching & dyeing	Chemical pulp and paper	Wood chemical	Synthetic rubber	Petroleum products	Canned, dried frozen fruits & vegetables	Soft drinks bottling	Leather tanning, general finishing processes	Hydraulic cement manufacture	Constituent mg/l
Alkalinity as $CaCO_3$	-	-	-	*200*	*150*	-	*250*	*85*	-	*400*
Acidity as $CaCO_3$	-	-	-	-	-	-	*0.0*	-	-	*0.0*
pH	*(3)*	*6-10*	*6-10*	*6.5-8.0*	*6.2-8.3*	*6.0-9.0*	*6.5-8.5*	-	*6.0-8.0*	*6.5-8.5*
Dissolved solids	*100*	-	-	*1.0*	-	*1.0*	*500*	-	-	*600*
Colour (Units) Organics	*5.0*	*30*	*10*	*20.0*	*20*	-	*5.0*	*10*	*5.0*	-
CCL4 Extract	-	-	-	-	-	-	*0.2*	*(4)*	*(5)*	*1.0*
Temperature (^0F)	-	-	*95*	-	-	-	-	-	-	-
Suspended solids	*5.0*	*10*	*10*	*30*	*5*	*10*	*10*	-	-	*500*

(Source: US Federal Water Pollution Control Administration, 1968.)

1. *Not to exceed U.S.Public Health Service drinking water standards.*
2. *Limit for non-carbonate harness. 70 mg/l as CaCO3.*
3. *Range from 2.5 to 1-.5 depending on process and product.*
4. *Carbon chloroform extract limit, 0.2 mg/l; also specified to be free of taste and odour.*
5. *Carbon chloroform extract limit, 0.2 mg/l.*

The Bureau of Indian Standards (BIS) has prescribed tolerance limits for wastewater generated from the industries as industrial effluents (Table- 3.10).

Table-3.10 Tolerance limits for industrial effluents (IS: 2490, Part-I-1981)

S. No	**Characteristic**	**Maximum tolerance limits for industrial effluents discharged (mg/l)**		
		Into inland surface water	**Into public sewers**	**On land for irrigation**
1	**2**	**3**	**4**	**5**
1	*Colour and odour*	*See Note 1*	-	*See Note No.1*
2	*Suspended solids*	*100*	*600*	*200*
3	*Particle size of suspended solids*	*Shall pass 850 micron IS Sieve*	-	-
4	*Dissolved solids (inorganic)*	*2100*	*2100*	*2100*
5	*pH value*	*5.5 to 9.0*	*5.5 to 9.0*	*5.5 to 9.0*
6	*Temperature* (^0C)	*Shall not exceed 40 in any section of the stream within 15 meters down stream from the effluent outlet*	*45 at the point of discharge*	-
7	*Oil and grease*	*10*	*20*	*10*
8	*Total residual chlorine*	*1*	-	-
9	*Ammonical nitrogen (as N)*	*50*	*50*	-
10	*Total Kjeldahl nitrogen (as N)*	*100*	-	-
11	*Free ammonia (as* NH_30	*5*	-	-
12	*Biochemical Oxygen demand (5 days at* 20^0 *C)*	*30*	*350*	*100*
13	*Chemical Oxygen Demand*	*250*	-	-
14	*Arsenic (as As)*	*0.2*	*0.2*	*0.2*
15	*Mercury (as Hg)*	*0.0*	*0.01*	-
16	*Lead (as Pb)*	*0.1*	*1*	-
17	*Cadmium (as Cd)*	*2*	*1*	-
18	*Hexavelant Chromium (as* Cr^6*)*	*0.1*	*2*	-
19	*Total Chromium (as Cr)*	*2*	*2*	-
20	*Copper (as Cu)*	*3*	*3*	-

1	2	3	4	5
21	*Zinc (as Zn)*	*5*	*15*	-
22	*Selenium (as Se)*	*0.05*	*0.05*	-
23	*Nickel (as Ni)*	*3*	*3*	-
24	*Boron (as B)*	*2*	*2*	*2*
25	*Percent sodium*	-	*60*	*60*
26	*Residual Sodium Carbonate (mg/)l*	-	-	*5*
27	*Cyanide (as CN)*	*0.2*	*2.0*	*0.2*
28	*Chloride (as Cl)*	*1000*	*1000*	*600*
29	*Fluoride (as F)*	*2.0*	*15*	-
30	*Dissolved phosphate (as PO_4)*	*5*	-	-
31	*Sulphate (as SO_4)*	*1000*	*1000*	*1000*
32	*Sulphide (as S)*	*2*	-	-
33	*Pesticides*	*Absent*	*Absent*	*Absent*
34	*Phenolic compounds (as C_6H_5OH)*	*1*	*5*	-
35	*Radioactive material*			
	a) Alpha emitters (uc/ml)	10^{-7}	10^{-7}	10^{-8}
	b) Beta emitters (uc/ml)	10^{-6}	10^{-6}	10^{-7}

Note:

All efforts should be made to remove colour and unpleasant odour as far as practicable.

If all these pollutants are present at the maximum permissible concentration, the effluent may lead to eutrophication. Therefore, data on ecological changes should be monitored.

*For paper, dyestuff, pesticides and certain chemical and petro-chemical industries, these values may be relaxed. Whenever these values are relaxed, it shall be ensured that the effluent passes the test for acute lethal toxicity as given in IS: 6582-1971***

3.4 WATER QUALITY CRITERIA FOR LIVESTOCK

There are many dissolved or suspended substances in waters that may be toxic from the point of view of livestock rearing. These may include inorganic elements and their salts, certain organic wastes from man's activities, pathogens and parasitic organisms, herbicides and pesticide residues, some biologically produced toxin and radio-nuclides.

The concentrations of these toxic substances, which render the water unsuitable for livestock is subject to a number of variables. These include age, sex, species and physiological state of the animals, water intake, diet and its composition, the chemical form of any toxic element present and the temperature of the environment.

3.4.1. Effects of Salinity

Excessively dissolved salts can cause physiological upset or death of live-stock (salt poisoning). The congregate effects of excessive presence of calcium, magnesium, sodium, sulphate, bicarbonate and chloride have been reported. Department of Agriculture, and government Chemical Laboratory of Western Australia have listed threshold concentration of salinity for various livestock which are given in Table-3.11.

In general it has been observed that waters containing less than 5000 mg/l dissolved salts can be used continuously for all livestock.

Table-3.11 Threshold concentration of Salinity for Various Livestock

Animal	Threshold Concentration (TDS in mg/l)
Poultry	*2860*
Pigs	*4290*
Horses	*6433*
Cattle dairy	*7150*
Cattle beef	*10,000*
Sheep	*12,900*

The animals can tolerate more salinity in water when fed on green feed in presence of low salt content feed.

3.4.2 Toxic Trace Elements

There are several other elements that occur naturally or as the result of man's activities at critical concentrations. The elements or ions become objectionable in water when their levels affect palatability of the water, become toxic to animals due to accumulation in tissues or body fluids, rendering the meat, milk, eggs or other edible products unsafe for human use. Guidelines for maximum limit of select elements and Ion for livestock drinking water (Alter Mercee & Wolf –1963) is given in Table-3.12.

Table-3.12 Guidelines for maximum limit of selected elements and ions for live stock drinking water (Mekee and Wolf – 1963)

Elements / ions	Maximum allowable limit (mg/l)
Cadmium	*0.05*
Arsenic	*0.20*
Boron	*5.00*
Chromium	*1.00*
Cobalt	*1.00*
Copper	*0.50*
Fluoride	*2.00*
Lead	*0.10*
Mercury	*0.01*
Nitrate-Nitrogen	*100.00*
Nitrite-Nitrogen	*10.00*
Selenium	*0.05*
Zinc	*25.00*

3.5 EFFECTS OF WATER QUALITY PARAMETERS ON HUMAN HEALTH AND DISTRIBUTION FOR VARIOUS USERS

It is essential to ensure that various constituents are within prescribed limits in drinking water supplies to avoid impact on human health (Table-3.13). Man, life forms and domestic animals are affected by alternation in water quality due to natural or anthropogenic reasons. The effect of these substances depends on the quantity of water consumed per day and their concentration in water. Likewise, the quality of irrigation water for agricultural use should be such that it does not impair plant growth or adversely affect the productivity of the land.

The water quality for various uses should be as per specification of water required for particular use. The probable effects of the water quality, on various uses are summarized in the Table-3.13 to 3.15.

Table-3.13 Effects of water quality parameters on human health when used for drinking purposes

S.No	Parameters	Prescribed limits IS:10500, 1991		Probable effects
		Desirable limit	*Permissible limit*	
1	*Colour (Hazen unit)*	*5*	*25*	*Makes water aesthetically undesirable*
2	*Odour*	*Essentially free from objectionable odour*		*Makes water aesthetically undesirable*
3	*Taste*	*Agreeable*		*Makes water aesthetically undesirable*
4	*Turbidity (NTU)*	*5*	*10*	*High turbidity indicates contamination / Pollution.*
5	*pH*	*6.5*	*8.5*	*Indicative of acidic or alkaline waters, affects taste, corrosivity and the water supply system*
6	*Hardness as* $CaCO_3$ *(mg/l)*	*300*	*600*	*Affects water supply system (Scaling), Excessive soap consumption, calcification of arteries. There is no conclusive proof but it may cause urinary concretions, diseases of kidney or bladder and stomach disorder.*
7	*Iron (mg/l)*	*0.30*	*1.00*	*Gives bitter sweet astringent taste, causes staining of laundry and porcelain. In traces it is essential for nutrition.*
8	*Chloride (mg/l)*	*250*	*1000*	*May be injurious to some people suffering from diseases of heart or kidneys. Taste, indigestion, corrosion and palatability are affected.*
9	*Residual Chlorine (mg/l) Only when water is Chlorinated*	*0.20*		*Excessive chlorination of drinking water may cause asthma, colitis and eczema.*

10	Total Dissolved Solids (mg/l) (TDS)	500	2000	Palatability decreases and may cause gastro intestinal irritation in human, may have laxative effect particularly upon transits and corrosion, may damage water system.
11	Calcium (Ca) (mg/l)	75	200	Causes encrustation in water supply system. While in sufficiency causes a severe type of rickets, excess causes concretions in the body such as kidney or bladder stones and irritation in urinary passages.
12	Magnesium (mg/l)	30	100	Its salts are cathartics and diuretic. High conc. May have laxative effect particularly on new users. Magnesium deficiency is associated with structural and functional changes. It is essential as an activator of many enzyme systems.
13	Copper (Cu) (mg/l)	0.05	1.50	Astringent taste but essential and beneficial element in human metabolism. Deficiency results in nutritional anemia in infants. Large amount may result in liver damage, cause central nervous system irritation and depression. In water supply it enhance corrosion of aluminum in particular
14	Sulphate (SO_4) (mg/l)	200	400	Causes gastro intestinal irritation along with Mg or Na, can have a cathartic effects on users, concentration more than 750 mg/l may have laxative effect along with Magnesium.
15	Nitrate (NO_3) (mg/l)	45	100	Cause infant methaemoglobinaemia (blue babies) at very high concentration, causes gastric cancer and affects adversely central nervous system and cardiovascular system.
16	Fluoride (F) (mg/l)	1.0	1.50	Reduce dental carries, very high concentration may cause crippling skeletal fluorosis.
17	Cadmium (Cd) (mg/l)	0.01		Acute toxicity may be associated with renal, arterial hypertension, itai-itai disease, (a bone disease). Cadmium salt causes cramps, nausea, vomiting and diarhoea.

18	Lead (Pb) mg/l	0.05		Toxic in both acute and chronic exposures. Burning in the mouth, severe inflammation of the gastro-intestinal tract with vomiting and diarrhoea, chronic toxicity produces nausea, severe abdominal pain, paralysis, mental confusion, visual disturbances, anaemia etc.
19	Zinc (Zn) (mg/l)	5	15	An essential and beneficial element in human metabolism. Taste threshold for Zn occurs at about 5 mg/l imparts astringent taste to water.
20	Chromium (Cr^6) mg/l	0.05		Hexavelant state of Chromium produces lung tumours can produce cutaneous and nasal mucous membrane ulcers and dermatitis.
21	Boron (B) (mg/l)	1.00	5.00	Affects central nervous system its salt may cause nausea, cramps, convulsions, coma etc.
22	Alkalinity (mg/l) $(CaCO_3)$	200	600	Impart distinctly unpleasant taste may be deleterious to human being in presence of high pH, hardness and total dissolved solids.
23	Pesticides: (m g/l)	Absent	0.001	Imparts toxicity and accumulated in different organs of human body affecting immune and nervous systems may be carcinogenic.
24	Phosphate (PO_4) (mg/l)	No guideline		High concentration may cause vomiting and diarrhoea, stimulate secondary hyperthyroidism and bone loss
25	Sodium (Na) (mg/l)	No guideline		Harmful to persons suffering from cardiac, renal and circulatory diseases.
26	Potassium (K) (mg/l)	No guideline		An essential nutritional element but its excessive amounts is cathartic
27	Silica (SiO_2) (mg/l)	No guideline		
28	Nickel (Ni) (mg/l)	No guideline		Non-toxic element but may be carcinogenic in animals, can react with DNA resulting in DNA damage in animals.
29	Pathogens (a) Total coliform (per 100 ml) (b) Faecal Coliform (per 100 ml)	1	10	Cause water borne diseases like coliform jaundice, Typhoid, Cholera etc. produce infections involving skin mucous membrane of eyes, ears and throat.

Table-3.14 Effects of water quality parameters in irrigation water on Plant growth and soils

S.No	Parameters	Prescribed limits IS:10500,1991		Probable effects
		DL	PL	
1	Salinity/EC in µs/cm at 25^{0}C	Sensitive Crops < 1500 Semitolerant 1500 – 3000 Tolerant crop > 3000		Plant growth is retarded with stunted fruits, leaves and stem in high salinity.
2	Sodicity/SAR	SAR < 10 10 – 18 18 – 26 > 26	Excellent Good Medium Bad	Causes defloculation of soil, restricting free movement of water
3	R.S.C.(meq/l)	< 1.25 1.25 – 2.5 > 2.5	Excellent Good Bad	Result in increase of sodium causing adverse effect.
4	Sodium (Na) %	No guideline		Increase total salinity, has adverse effect on sodium sensitive species such as stone fruit trees and avocados. Effects soil structure & permeability.
5	Chloride (Cl) (mg/l)	No guideline		May have direct toxic effects along with sodium.
6	Nitrate (NO_3) (mg/l)	No guideline		An essential plant nutrient but its excess may delay maturity and seed growth in some plants..
7	Boron (B) (mg/l)	Sensitive crops < 10 Semi tolerant crops 1.0 – 2.0 Tolerant crops 2.0 – 4.0 Unsatisfactory for most crops > 4.0		An essential plant nutrient at low concentration but high conc. are toxic to plant.
8	Copper (Cu) (mg/l)	0.20^a	5.00^b	Essential for plants as a micro nutrient. Deficiency may cause crop damages, chlorosis also leading to dieback of plant.
9	Lead (Pb) (mg/l)	5.20^a	10.00^b	Some plants accumulate it, which may have harmful effects on human health. Very high concentration may reduce root growth.

S.No	Parameters	Prescribed limits IS:10500,1991		Probable effects
		DL	PL	
		2.00[a]	*10.00*[b]	*An essential plant nutrient as activator of enzymes. Deficiency leads to several diseases such as by lonising, rosette or little leaf. High concentration produces toxic effects.*
11	*Chromium (Cr) (mg/l)*	*0.10*[a]	*0.10*[b]	*Toxic to plants. Very high conc. may reduce growth, produce iron deficiency in plants and reduce the yields.*
12	*Cadmium (Cd) (mg/l)*	*0.01*[a]	*0.05*[b]	*Reduces plant growth, bio-accumulates in plants, cause adverse effects (ilai-ilai) on human consumption, reduces yields.*
13	*Iron (Fe) (mg/l)*	*5.0*[a]	*20.0*[b]	*An important and essential element. Deficiency caused by excess of lime in soils, results in chlorosis. Excess iron contributes to soil acidification.*
14	*Nickel (Ni) (mg/l)*	*0.20*[a]	*2.0*[b]	*Cause stunded growth of plant in the concentration 0.5 mg/l. Toxic to barley, beans, Oats, when more than 2.0 mg/l.*

a = Continuous use; *b = Short term use on fine texture soils.*

Table-3.15 Effects of water quality parameters in water on Livestock

S.No	**Parameters**	**Prescribed Limits IS:10500, 1991**		**Probable effects**
		Desirable limit	**Permissible limit**	
1	*Salinity (Total soluble salts mg/l)*	*1000*	*3000*	*High salinity may cause diarhoea, a risk to pregnant/lactating animals and increases mortality.*
2	*pH*	*6.5*	*8.2*	
3	*Boron (mg/l)*	*1.0*	*5.0*	*No definite effect*
4	*Cadmium (mg/l)*	*0.01*	*0.05*	*Cause permanent sterility, reduced longevity and malformation in foetus.*
5	*Chromium (mg/l)*	*0.00*	*0.01*	*Not readily absorbed in animal tissue.*
6.	*Copper (mg/l)*	*0.1*	*0.5*	*Most livestock (except sheep) tolerate rather high levels*
7	*Iron (mg/l)*	*No limit recommended*		
8	*Lead (mg/l)*	*0.05*	*0.1*	*High levels may cause poisoning*
9	*Zinc (mg/l)*		*25*	*Relatively non-toxic animals. Very high levels may cause reduced water consumption, egg production and body weight.*
10	*Nitrates (mg/l)*	*10*	*100*	*Leads to methaemoglobinaemia, erosion and hemorrhage of gastric mucus leading to death. Cause reduction in plasma and vitamin A in liver.*
11	*Pesticides*	*Absent*	*0.001*	*Non-lethal doses may affect growth rate, egg production and viability of the young.*
12	*Pathogens*			*Water contaminated with parasitic organisms cause infection, serious livestock losses. Infected water may be a source for listeriosis, cause urinary disease and mastitis in livestock.*
13	*Fluorides (mg/l)*	*1.0*	*2.0*	*High levels lead to tooth mottling and transferred into milk and eggs.*

Table-3.16 Effects of water quality parameters in water for industries.

S. No	Parameters	Prescribed Limits IS:10500, 1991		Probable effects
		Desirable limit	Per-missible limit	
1	*pH value*	*6.5*	*8.2*	*Low pH increases corrosion of concrete, pH 7.0 is required for most industry, pH 2.7 – 7.2 advised for carbonated beverage industry*
2	*Total dissolved solids (mg/l)*	*500*	*3000*	*Causes foaming in boilers and solids interfere with clearness, colour or taste of finished products, low TDS values are required in most industries. High TDS leads to corrosion.*
3	*Iron (mg/l)*	*0.1*	*2.0*	*Recommended values for food processing units is 0.2, for paper and photographic industry iron of 0.1 mg/l is recommended iron less than 0.1 mg/l is recommended in cooling waters.*
4	*Chloride (mg/l)*	*25*	*200*	*Significantly effect the rate of corrosion of steel and Aluminum.*
5	*Fluoride (mg/l)*	*0.2*	*1.0*	*Harmful in industries involved in production of food beverages, pharmaceuticals and medical items.*
6	*Calcium (mg/l)*	*20*	*500*	*High Calcium leads to spots on films. Have undesirable effects like forming of emulsions and processing of colloids upsetting fermentation process, and electroplating rinsing operation*
7	*Magnesium (mg/l)*	*5*	*30*	
8	*Sulphate (mg/l)*	*25*	*250*	*Increases corrosiveness of water towards concrete, low sulphates (20 mg/l) is recommended for sugar industries.*
9	*Nitrate (mg/l)*	*15*	*30*	*Injurious to dyeing of wool and silk fabrics and harmful in fermentation process for brewing. Nitrate in some water protects metal in boilers from inter-crystalline cracking.*
10	*Copper (mg/l)*	*0.01*	*0.5*	*Copper is undesirable in food industry as it has colour reactions and imparts fish taste to finished products. Affects smoothness and brightness of metal deposits in metal plating, baths.*
11	*Chromium (mg/l)*	*N.A*	*N.A*	*It is a corrosion inhibitor.*
12	*Zinc*	*N.A.*	*N.A.*	*Zinc bearing water should not be used in Acid drinks like lemonade.*
13	*Lead*	*N.A.*	*N.A.*	*Traces of lead in metal plating baths will affect smoothness and brightness of deposits.*

Chapter-4

DISTRIBUTION OF NITRATE IN GROUND WATER SYSTEM

Nitrate is one of the major indicator of anthropogenic sources of pollution. The negative change and high mobility favours its persistent nature and transport along the ground water flow path. Nitrate is the ultimate oxidized product of all nitrogen containing matter and its occurrence in ground water can be fairly attributed to infiltration of water through soils containing domestic, vegetable and animal waste, fertilizer and industrial pollution. As the lithogenic sources of nitrogen are very rare, its presence in ground water is almost always due to anthropogenic activity.

4.1 HEALTH EFFECTS

NO_3 is an oxidising agent and it readily oxidizes hemoglobin (Hb) in to methaemoglobin (MeHb) a blue coloured pigment and gets reduced to NO_2. The oxidized Hb impairs seriously the oxygen carrying capacity of the blood and thus causes hypoxia, which may have fatal consequences in anemic individuals and infants under 8 weeks of age. The MeHb formed in the infant blood gives a characteristic bluish color to the skin and mucous membrane, thus giving the name "blue baby Syndrome". This condition is particularly important in the case of infants because the infant and the foetal – Hb, which is $\propto_2\gamma_2$ type has greater affinity for oxygen (O_2) than adult Hb which is $\propto_2\beta_2$ type. This condition may also result by birth due to the deficiency of an enzyme known as methaemoglobin reductase in the foetal blood. This enzyme catalyze the reversion of MeHb to Hb as follows.

$$\text{Me-Hb} \xleftrightarrow{\textit{Reductase}} \text{Hb}$$

Thus the Me-Hb formed in the fetal blood severely impairs the oxygen carrying capacity of the blood in infants, causing the blue baby disease. Thus, infants are most susceptible to NO_3 more than 45 mg/l of nitrate, for at least 4 months, by which time the fetal blood gets converted to adult Hb.

In addition to methemoglobinemia, nitrate may get reduced to Nitrite (NO_2) in the intestinal tracts, which may further react with amino acids to form nitrosoamines which are potential carcinogens. Consumption of water containing high Nitrate may cause adverse effects on the cardiovascular system and central nervous system.

Considering the adverse effects of nitrate BIS has recommended 45 mg/l as the maximum permissible limit in water used for drinking as there is no evidence of its requirement to human beings.

4.2 NITRATE INCIDENCE IN GROUND WATER IN TAMIL NADU

In Tamil Nadu as per data available with CGWB, distribution of nitrate ranges from 0.05 to 660 mg/l in phreatic aquifer with the maximum value noticed at Hanuman Nagar, Dindigul district. In the deeper aquifer it ranges from 0 to 790 mg/l and maximum value obtained at Kayathar, Tuticorin district.

District-wise minimum & maximum value of nitrate noticed both deeper & phreatic aquifer are presented in Table-4.1. It is observed that ground water in the shallow aquifers, in general, richer in nitrate in comparison to the deeper aquifers establishing the fact that it is directly related to anthropogenic activities. However, some bore wells drilled in the districts of Erode (max. 437 mg/l, Trichy (max. 92 mg/l), Tuticorin (max. 790 mg/l), Tirunelveli (max. 143 mg/l) and Tiruvallur (max. 124 mg/l) showed higher values of nitrate may be due to interconnection of fractures zones with the weathered zone. About 90% of the wells drilled in deeper aquifer were found to have nitrate below the BIS limit of 45 mg/l.

Table-4.1 District-wise minimum & maximum value of Nitrate (mg/l) for different aquifers

Sl. No	District	Nitrate in shallow aquifer		Nitrate in deeper aquifer	
		Min	Max	Min	Max
1	Chennai	1.1	20.83	1.32	8.56
2	Coimbatore	2.0	565	7	37
3	Cuddalore	1.4	36.4	0.17	31
4	Dharmapuri	8	271	0.98	418
5	Dindigul	3	660	0.28	70.62
6	Erode	3	311	0	437
7	Kancheepuram	0.47	52.93	0	19.17
8	Kanyakumari	2.0	232	9.08	
9	Karur	5	306	0.72	22
10	Krishnagiri			0	288
11	Madurai	5	93	0.07	59
12	Nagapattinam	0.28	50.2	0.3	0.5
13	Namakkal	26	579	27	461
14	Nilgris	14	166		
15	Perambalur	2.0	52	0	76
16	Pudukkottai	2	606	0.01	15
17	Ramanathapuram	5	435	5	9
18	Salem	2	384	1	747
19	Sivagangai	3	35	9	116
20	Thanjavur	0.1	43.8		
21	Theni	5	270	0.97	23
22	Thiruvallur	0.14	27.5	0	14
23	Thiruvannamalai	0.05	52.8	0.06	51
24	Tiruchirapalli	2	138	0	179
25	Tirunelveli	2	409	0.5	143
26	Tiruvarur	0.5	35.6	0.57	
27	Tuticorin	1	655	14	790
28	Vellore	6.6	320	0	52.4
29	Villupuram	0.6	155	0	98
30	Virudhunagar	5	146	1	73

GROUND WATER CONTAMINATION BY GEOGENIC POLLUTANTS

Ground water geogenic problem due to the presence of Fluoride and Arsenic in ground water is discussed below.

5.1 DISTRIBUTION OF FLUORIDE IN GROUND WATER SYSTEM (SHALLOW AND DEEPER AQUIFERS)

High fluoride ground water is a considerable health problem in several regions of the world. At least 25 countries across the globe have high concentration of fluoride in ground water. In India there is an increasing incidence of Fluorosis, both dental and skeletal. High fluoride ground waters are present especially in hard rock aquifer regions of Tamil Nadu possibly due to geological environment, which is a matter of concern and need immediate remedial measures.

5.1.1 BASIC FACTS ABOUT FLUORIDE

Due to its high reactivity fluoride does not occur in elemental state in nature. It accounts for about 0.3 gm/Ton of the earths crust and exists in the form of fluoride in a number of minerals, of which fluorspar, cryolite, fluor-apatite and amphiboles such as hornblende, biotite etc. are the most common . Fluoride enrichment in ground water takes place mainly through leaching and weathering of the fluoride bearing minerals present in the rocks and sediments (Table-5.1) and the duration of the interaction between fluoride bearing minerals and ground water. Fluoride may also be introduced to the environment due to burning of coal and during manufacturing process of aluminium, steel, bricks etc. In the phosphatic fertilizers, fluoride is an impurity, which results in high fluoride concentration in the soils. Thus accumulation of fluoride in the soils due to anthropogenic activities eventually results in leaching by percolating water and ultimately increase the fluoride level in ground water regime.

Table –5.1 Fluoride in Rocks (Keller,1979)

Sl.No	Rocks	Fluoride Range (mgm/kg)	Average
1	Basalt	20-1060	360
2	Granites and Gniess	20-2700	870
3	Shale and Clays	10-7600	800
4	Limestone	0-1200	220
5	Sandstone	10-880	180
6	Phosphate	24000-41500	31000
7	Coal ash	40-480	80

5.1.2 INCIDENCE OF FLUORIDE IN GROUND WATER

In Tamil Nadu, the distribution of fluoride in ground water ranges from 0.02 to 3.21 mg/l in phreatic aquifer, with the maximum value observed at Idapadi of Salem district. In the deeper aquifers it ranges from 0.03 to 4.5 mg/l with the maximum value observed at Valayur in Trichy district. Comparatively high values are observed in deeper aquifers in some parts of Trichy, Erode, Dharmapuri, Dindigul, Krishnagiri, Karur and Salem districts. District-wise minimum & maximum value of fluoride observed in both shallow and deeper aquifers are presented in Table-5.2. Distribution of fluoride in shallow aquifers presented in Plate- 5.1.1. Another important observation is the distinctive correlation between high Fluoride ground water and geological environment of the deeper aquifers. The predominant formations of hard rock areas of Tamil Nadu are Granites Gneiss and Charnokite. Among these formations fluoride distribution is observed to be very high in some Granites and Gneiss shown as Plate 5.1.2 below. Fluoride concentration in ground water in the hard rock aquifer is correlated with the concentration of certain major dissolved constituents. It is observed that fluoride is inversely related to dissolved Calcium and Magnesium in some areas. Moderately high fluoride levels (>2 mg/l) nearly always have been found to occur in ground water with calcium contents of less than 100 mg/L except in few Granites and Gneiss formation. Ground water at location having high fluoride (>4 mg/l) had a very low dissolved calcium content of 32 mg/l. In some Granites and Gniess formation where fluoride content(>2 mg/l) the magnesium content found to be less than calcium. It is also observed that fluoride in ground water can be correlated to pH. Moderate to high fluoride observed in some deeper aquifer may be due to dissolution of Ca/Mg fluoride minerals present in the formation.

5.1.3 SUM UP.

Study of the analytical results of ground water samples collected from the phreatic aquifers of Tamil Nadu indicate that concentration of fluoride in excess of permissible limits for drinking water uses, in most cases, may be due to the dissolution of fluoride bearing minerals in granites and gneisses. Anthropogenic activities may also be contributing to fluoride enrichment in ground water to some extent. It is also observed that ground water in deeper fractured aquifers is more prone to fluoride contamination in comparison to phreatic aquifers.

Table-5.2 District-Wise Minimum & Maximum concentration of Fluoride in Shallow and Deeper Aquifers

Sl.No	District	Fluoride in shallow aquifer *(mg/l)*		Fluoride in deeper aquifer *(mg/l)*	
		Min	Max	Min	Max
1	Chennai	0.099	0.546	0.88	1.12
2	Coimbatore	0.14	1.68	0.1	1.14
3	Cuddalore	0.03	1.24	0.21	0.92
4	Dharmapuri (Composite)	0.02	1.78	0.34	1.74
5	Dindigul	0.26	1.7	0.74	2.4
6	Erode	0.14	2.02	0.38	2.5
7	Kancheepuram	0.083	0.683	0.2	1.07
8	Kanyakumari	0.01	1.26	1.03	
9	Karur	0.33	1.57	0.14	3
10	Madurai	0.15	1.4	0.38	1.13
11	Nagapattinam	0.051	0.746	0.15	0.77
12	Namakkal	0.26	2.02	0.28	2.55
13	Nilgris	0	0.13		
14	Perambalur	0.503	1.642	0.67	2.01
15	Pudukkottai	0	1.68	0.5	1.4
16	Ramanathapuram	0.02	1.7	0.5	1.3
17	Salem	0.06	3.21	0.34	1.89
18	Sivagangai	0.03	1.75	0.96	1.18
19	Thanjavur	0.025	0.862		
20	Theni	0.14	1.6	0.55	2.6
21	Thiruvallur	0.031	0.919	0.32	1.46
22	Thiruvannamalai	0.1	0.79	0.28	1.49
23	Tiruchirapalli	0.15	0.85	0.22	4.5
24	Tirunelveli	0.02	1.31	0.03	1.47
25	Tiruvarur	0.021	0.867	0.07	
26	Tuticorin	0.16	1.12	0.03	1.26
27	Vellore	0.39	1.64	0.27	3.04
28	Villupuram	0.2	1.935	0.18	1.44
29	Virudhunagar	0.36	1.18	0.19	1.78

PLATE-5.1.1

CENTRAL GROUND WATER BOAD, SECR, CHENNAI

DISTRIBUTION OF FLUORIDE IN PHREATIC AQUIFERS, TAMIL NADU

[MAY - 2004]

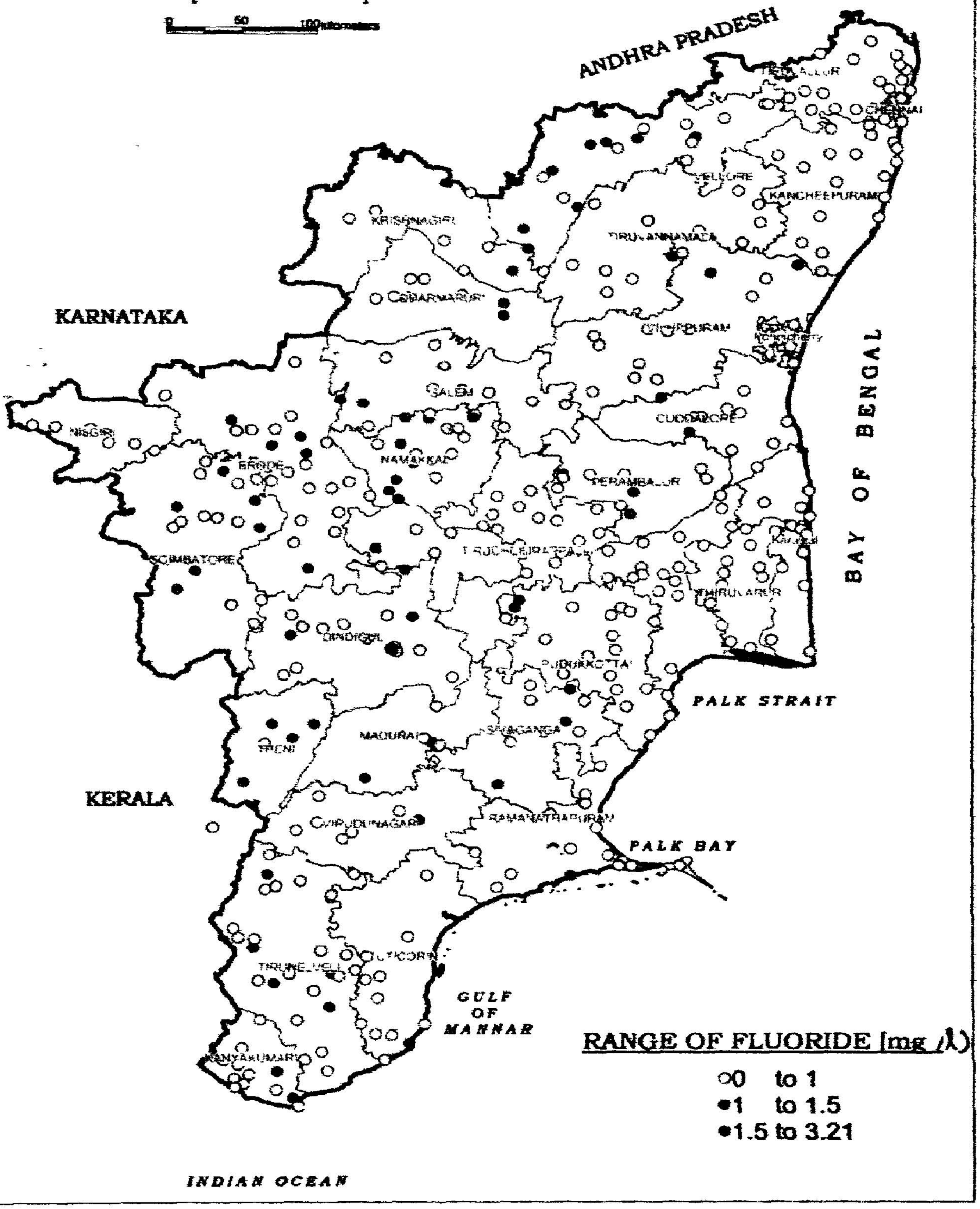
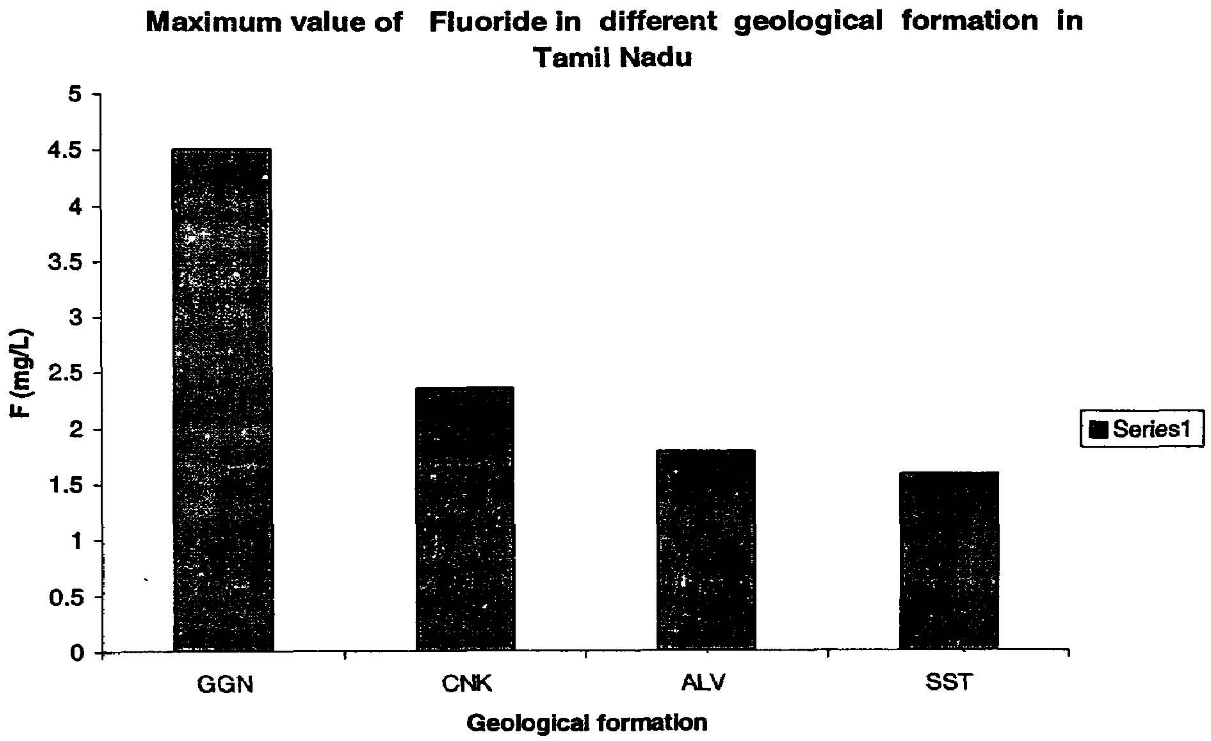


Plate 5.1.2



GGN	-	Granitic Gneiss
CNK	-	Charnockite
ALV	-	Alluvium
SST	-	Sandstone

5.2 DISTRIBUTION OF ARSENIC IN GROUND WATER IN TAMIL NADU

5.2.1 SOURCE OF ARSENIC IN NATURAL WATER AND TOXICITY

Arsenic is a shiny, gray, brittle element possessing both metallic and non-metallic properties. Even when it is present, water is colourless, tasteless and odourless making it almost impossible for people to know that water is contaminated. In the natural environment, it occurs in the soil at an average concentration of about 5-6 mg/kg. Geochemical characteristics of the aquifer material and their interactions with the aqueous media play an important role in controlling retention and/or mobility of arsenic within the subsurface environment. Similarly uncontrolled anthropogenic activities such as smelting of metal ores, use of arsenical pesticides and wood preservation agents may also release arsenic directly to the environment.(Bhattacharya, Chatterjee and Jacks ,1995). Most fruits, vegetables, meats and fishes contain arsenic. Arsenic levels in seawater and sea fishes may be as much as 5 mg of arsenic/kg. The occurrence and origin of arsenic in ground water depends on several factors such as adsorption-desorption, oxidation-reduction, precipitation-dissolution, ion-exchange, grain size, organic content, biological activity and aquifer characteristics. However, it is widely believed that arsenate is the major water soluble species in ground water because arsenite is usually prevalent in anaerobic condition.

Based on the environmental factors, socio-economic factors and food habit; the Bureau of Indian standards (BIS) has set a maximum permissible limit of 50 μg/l of Arsenic in drinking water and the WHOs recently revised guideline value is also 50 μg/lit. The toxicology of arsenic is a complex phenomenon as arsenic is considered to be an essential element also. The speciation of Arsenic determines its toxicity and its pathways in human physiology. The toxicity decreases from Arsenic (III) to Arsenic (V) to Organo Arsenic. As (III) is more mobile than As (V). In fact, As (III) is 60 times more toxic than As (V). The inorganic Arsenic compounds are about 100 times more toxic than its methylated forms. Excessive intake of Arsenic in the human body causes health hazards and is manifested in the form of arsenic poisoning. The fatal disease caused by over intake of Arsenic is called Arsenecosis. In irrigation water maximum recommended concentration is 0.1mg/l (Mehta,B.C,2004)

5.2.2 RESULTS AND DISCUSSIONS

Arsenic contamination of ground water has emerged as a major health hazard in many parts of the world in recent years. In India, Arsenic in ground water was first noticed in parts of West Bengal, where it has assumed serious proportions, affecting a large number of people depending on ground water for drinking water supply. As part of the nation-wide initiative by CGWB to have basic data of arsenic occurrence in ground water, 405 ground water samples were collected from observation wells in Tamil Nadu during May 2003 and analysed.

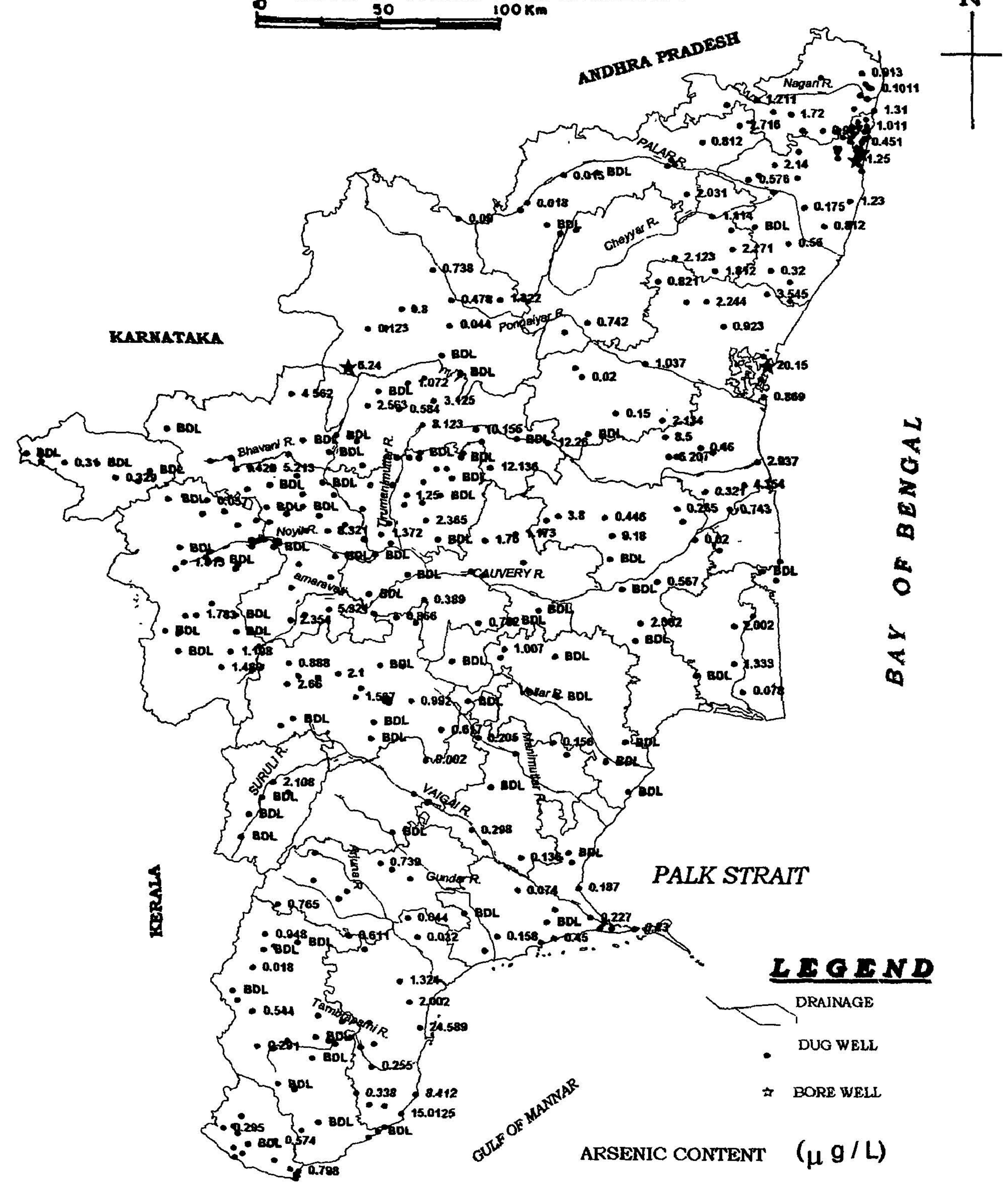
All the water samples were analysed for total Arsenic content (as As) in μg/l and found to be within desirable limit. Distribution of arsenic contents are presented in **Plate-5.2.1** and discussed in the following paragraphs. Ground water samples were classified depending on the sampling location as urban/industrial and agricultural. 51.73% samples were identified as urban/industrial and 48.27% as agricultural. District-wise minimum, maximum and average values of arsenic in groundwater of Tamil Nadu presented in Table-5.3.

Table – 5.3 District-wise Minimum, Maximum And Average Values Of Arsenic (µg/l) in Groundwater Of Tamil Nadu

District Code No	District	No of Samples analysed	Minimum (µg/L)	Maximum (µg/L)	Percentage of samples having Arsenic above BDL	Average (µg/L)
1	Tiruvallur	17	0.1011	2.170	94	1.01641
2	Coimbatore	42	0.038	4.602	57	0.90985
3	Dharmapuri	11	0.044	1.322	73	0.53485
4	Kanyakumari	14	0.123	3.421	71	0.611
5	Chennai	14	0.136	2.636	100	1.0604
6	Madurai	5	0.002	0.090	80	0.436
7	Nilgri	8	0.31	0.513	37	0.37025
8	Vellore	12	0.015	2.176	75	0.92835
9	Ramanathapuram	18	0.074	0.490	72	0.2735
10	Salem	15	0.584	12.136	73	5.13175
11	Cuddalore	9	0.367	8.500	100	2.868775
12	Pudukottai	8		1.007	12	1.007
13	Trichy	8	1.173	6.560	37	4.72825
14	Thanjavur	8	0.02	2.302	50	0.724
15	Tirunelveli	25	0.018	1.519	60	0.5045
16	Erode	32	1.428	8.654	53	5.0225
17	Dindigul	21	0.058	2.660	67	1.1475
18	Virudhunagar	9	0.09	7.901	78	1.879
19	Sivaganga	7	0.136	0.205	28	0.16325
20	Tiruvannamalai	11	0.658	3.141	91	1.70525
21	Tuticorin	17	0.032	24.589	94	4.9912
22	Nagapattinam	3		0.078	33	0.078
23	Villupuram	10	0.02	3.545	90	1.38
24	Karur	8	0.389	0.849	50	0.94025
25	Perambalur	8	0.083	9.180	25	3.4165
26	Namakkal	21	1.235	8.940	57	3.0877
27	Theni	5	0.087	2.108	40	1.0975
28	Kancheepuram	29	0.16	4.500	89	1.251
29	Tiruvaur	3	1.333	2.002	67	3.335

PLATE - 5.2.1

DISTRIBUTION OF ARSENIC CONTENT IN GROUND WATER IN TAMIL NADU STATE & U.T.OF PUDUCHERRY



BDL - BELOW DETECTION LIMIT

5.3 PRESENCE OF ARSENIC DUE TO EFFECT OF SEWAGE, WASTE DISPOSAL, AGRICULTURE AND INDUSTRY

The Chennai city sewerage system is over loaded and the city drainage channels such as Coouam, Adyar, Otteri Nullah and the Buckingham are often little better than open sewers. The hut-dwellers have no access to sewers for waste disposal and substantial population of oxen, cow and buffaloes contribute to the sewage problem. Chennai has a wide range of industries ranging from large scale tanneries, Engineering workshop, textile factories etc. located in and around the city (Somasundaram, Ravindran and Tellam,1993). A total of 35 water samples were collected from dug wells and bore wells in Chennai and parts of Tiruvallur and Kancheepuram districts. Distrbution of Arsenic in these samples are shown in **(Plate- 5.2.2)**. It is observed that comparatively higher amounts of arsenic are found in the upstream side of the drainage channels, possibly due to the leaching effect of urban sewage and chemicals used in industries. Maximum value of Arsenic was recorded obtained in phreatic aquifer (4.5µg/l) at Nellankarai, whereas in semi-confined / confined aquifers (2.9µg/l) at Kandanchavadi near the upstream of Buckingham drainage channel of Kancheepuram district . The content of arsenic is more in phreatic aquifer than the semi-confined / confined aquifers possibly due to unplanned urban and industrial activities. In Chennai district, maximum value obtained at Kodambakkam dugwell (2.636µg/l) near the Coovam drainage channel is probably due to leaching effect of urban sewage as the area is densely populated. Similarly, in Tiruvallur district maximum value obtained at Perumalnagar dugwell (2.17 µg/l) near the upstream of Coovum may be due to the effect of Urban sewage. Higher values of Arsenic obtained around the city may be due to the industrial and waste disposal activities

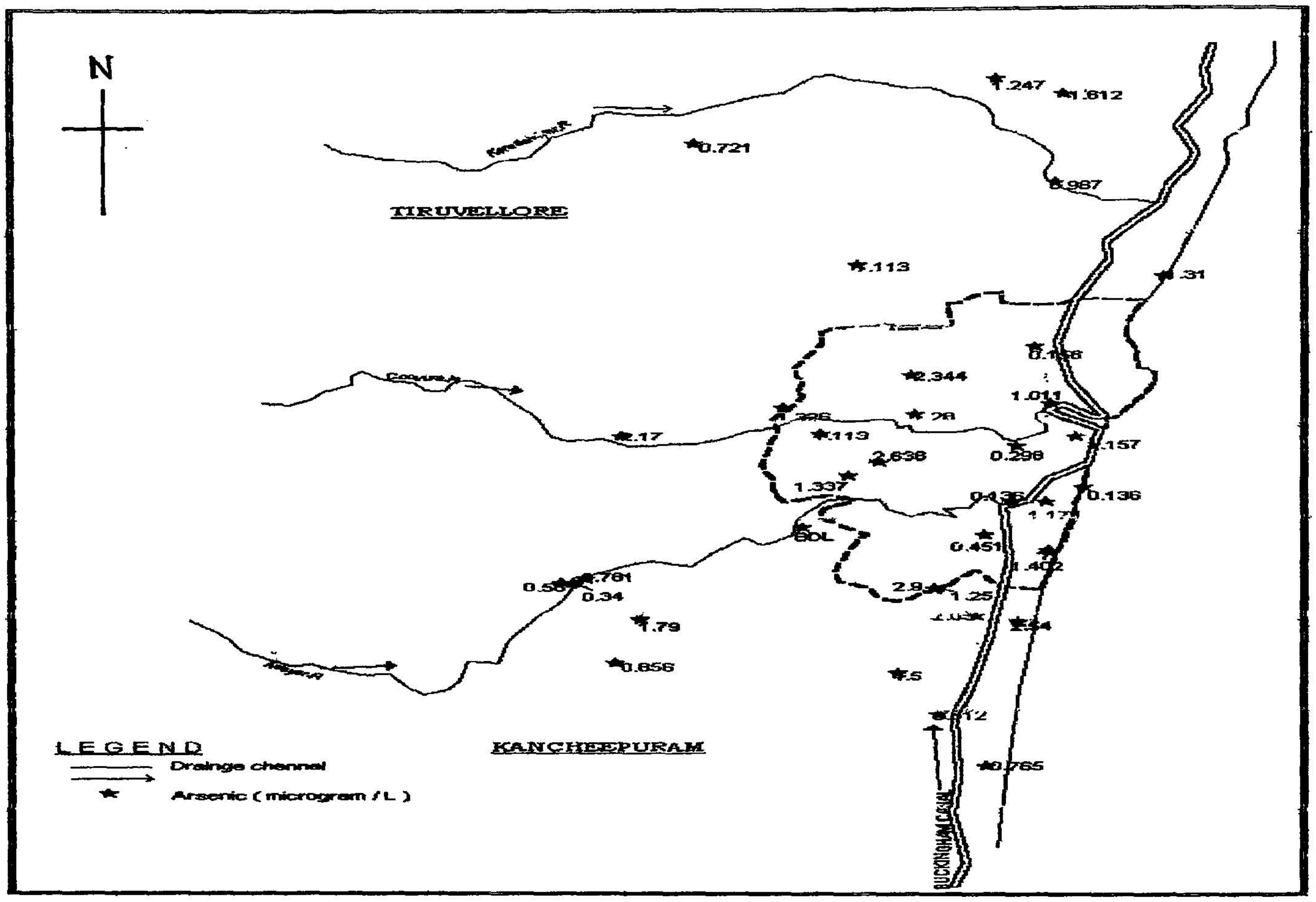
A total of 43 water samples were also collected from dug wells in Coimbatore district . The concentration of Arsenic in 18 samples were found to be BDL and in the rest of the samples, maximum Arsenic content was of 4.602 µg/l at Tirupur-Semmudu surveillance well. Tiruppur is famous for knitwear manufacture and export. It is located about 50 kms east of Coimbatore city. There are about 775 bleaching and dyeing industries concentrated mainly along the bank of Noyyil river, a tributary of river Cauvery. About 80-95% of the used water is converted in to the effluent.The industrial units discharge about 100 MLD of treated and untreated effluents in to the Noyyil drainage channel and high concentration of chromium and iron were noticed above the BIS limit in Tirupur area in ground water (Rameshkumar, Padmavathi and Karuppiah 2003). Appreciable amount of Arsenic was noticed in all the water samples from the dug wells and the down stream of Noyyil drainage channel (3.895µg/l) at Tirupur industrial area. This may be due to the use of various chemicals for dyeing, bleaching and other processes which ultimately found their way in Noyyil drainage channel and the phreatic aquifer contaminated due to the leaching effect of industrial effluents.

5.4 PRESENCE OF ARSENIC IN URBAN/INDUSTRIAL AREA

Average concentration of Arsenic varied from 0.308 to 8.150 µg/l in urban/industrial areas. Maximum value was noticed in Salem district, which may due to mininig, steel industries, food processing industries and waste disposal from urban areas. Ground water in districts like Erode, Dindigul, Karur, Dharmapuri, Vellore, Ramanathapuram, Pudukottai, Tuticorin,

Plate-5.2.2

Distrbution of Arsenic in Ground Water in and around Chennai



Nagapatinum,Villupuram, Perambalur have comparatively higher values of arsenic in urban/ industrial areas probably due to the effect of ,tanneries, food processing, textile and dyeing industries etc. and other anthropogenic activities. Ground water in parts of Salem, Erode and Dharmapuri districts showed higher concentration of Arsenic near the drainage channels. The average concentration of Arsenic in urban/industrial areas were found to be more than the agricultural area. Thus Arsenic content in phreatic aquifer may be due to the uncontrolled anthropogenic activities.

5.5 PRESENCE OF ARSENIC DUE TO AGRICULTURE ACTIVITIES

The average concentration of Arsenic in agricultural lands varied from 0.239 to 6.56 µg/l. Application of fertilizers and pesticides may be the reason for arsenic in ground water in these areas.

From the foregoing discussions it is concluded that in the major part of Tamil Nadu, the level of Arsenic in the formation water is much below the permissible limit (50 µg/l). The concentration of Arsenic varied from 0.002 to 24.589 µg/l in phreatic aquifers.where as in semi-confined / confined aquifers, it ranged from 1.25 to 2.9 µg/l. The presence of Arsenic is more in phreatic aquifer when compared to semi-confined/confined aquifer in urban/industrial areas, which may be due to groundwater contamination associated with urbanisation and industrialization Appreciable amounts of Arsenic is observed in ground water in the vicinity of a few drainage channels as well, possibly due to agricultural/unplanned urban and industrial activities. Thus it is opined that due to uncontrolled anthropogenic activities such as rapid industrialisation, urbanisation and agricultural practice may increase the Arsenic content in ground water in course of time.

CASE STUDIES

Ground water pollution studies have been carried out during various field season programmes in Tamil Nadu. The following case studies are discussed in this chapter. The location map of these case study areas is given as Plate-6.1.1.

1) Manali Industrial Area, North Chennai,
2) Tannery belt of Dindigul district ,
3) Tannery belt of Vellore district,
4) Upper Palar Basin,
5) Tiruppur Industrial area, Coimbatore dist.
6) Ambattur Industrial Area, Tiruvallur dist., and
7) Chrompet area, Kancheepuram dist.

6.1 GROUNDWATER POLLUTION IN MANALI INDUSTRIAL AREA, NORTH CHENNAI

Ground Water Pollution studies were carried out in Manali Industrial Area, North Chennai, Tamil Nadu during AAP 2001-02.

6.1.1 BACK GOUND INFORMATION

Manali Industrial area falls in Manali Town Panchayat, Puzhal Panchayat Union, Ambattur taluk, Tiruvallur district, Tamil Nadu. About 85 Sq. Km has been taken up for the study. The study area is a coastal plain drained by Korttalaiyar river and its tributaries. Surface water flow in them is seasonal. Backwater occupies part of the river course during the major part of the year. Buckingham canal traverses through the central part of the study area from south to north and also functions as a carrier of various types of urban and industrial pollutants. All the surface water sources are highly polluted.

Manali industrial area has a total of 59 industrial units. The normal annual rainfall ranges from 1208.5 to 1247.6 mm. About 80 percent of the annual rainfall is received during October and November. On an average there are about 53 rainy days in a year. The entire area is covered by coastal alluvium.

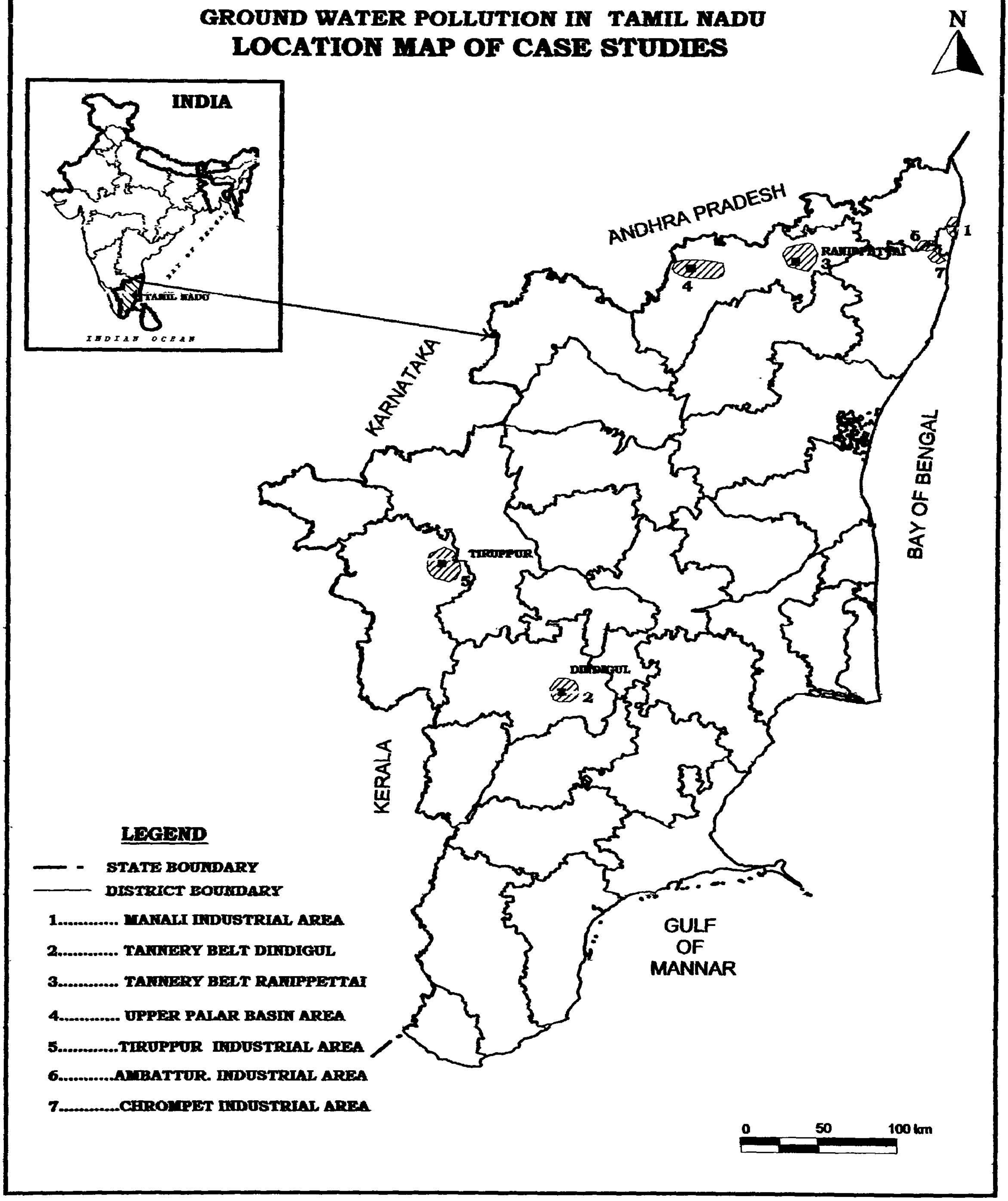
Ground water occurs under phreatic conditions and it is developed by means of dug wells, shallow tube wells, driven wells fitted with hand pumps and dug wells with radial arms. The depth to water level during post monsoon ranged from 0.82 to more than 9 m bgl and in major part of the area it was less than 2 m bgl. Seasonal fluctuation (May 2001- January 2002) in the study area ranged upto 2.1 m. The annual fluctuation ranged upto 1.2 m Long-term trend of water level shows that there is a declining trend, which ranged from 0.06 – *0.124 m/year.*

PLATE - 6.1.1

CENTRAL GROUND WATER BOARD, SECR, CHENNAI

GROUND WATER POLLUTION IN TAMIL NADU

LOCATION MAP OF CASE STUDIES


N
INDIA
TAMIL NADU
INDIAN OCEAN
ANDHRA PRADESH
KARNATAKA
KERALA
BAY OF BENGAL
GULF OF MANNAR
RANIPPETTAI
TIRUPPUR
DINDIGUL
1
2
3
4
5
6
7
LEGEND
STATE BOUNDARY
DISTRICT BOUNDARY
1............ MANALI INDUSTRIAL AREA
2............ TANNERY BELT DINDIGUL
3............ TANNERY BELT RANIPPETTAI
4............ UPPER PALAR BASIN AREA
5............TIRUPPUR INDUSTRIAL AREA
6...........AMBATTUR. INDUSTRIAL AREA
7...........CHROMPET INDUSTRIAL AREA
0
50
100 km

The quality of ground water is very poor except in the west Central and South –western parts and isolated pockets in the eastern part of the study area. The study area experiences the threats of (i) erosion of sea coast (ii) indiscriminate dumping of municipal/industrial solid wastes (iii) water logging (iv) pollution due to industrial effluent (v) water table depletion (vi) sea water intrusion and (vii) depletion of natural recharge area. These problems have affected the hydrochemistry of ground water in the study area. The area affected by various pollutions pictorially depicted as Plate –6.1.2.

6.1.2 RESULTS OF THE STUDY

The electrical conductivity of formation water ranged upto 36,000 µs/cm at 25^0C. The level of Calcium ranges upto 580 mg/l. Magnesium ranges upto 888 mg/l. Sodium ranges upto 8900 mg/l. Potassium ranges upto 200 mg/l. Chloride ranges upto 3369 mg/l. Sulphate ranges upto 2544 mg/l. Nitrate ranges upto 347 mg/l. Fluoride ranges upto 4.1 mg/l.

Toxic heavy metals are present in the industrial effluents, surface water sources and formation waters. The toxic heavy metal ion concentration is high in the areas, where the industrial activity is more and is the least where the industrial activity is less (Plate-6.1.3). The concentration of Zinc and Chromium in industrial effluents, surface water sources and formation water samples are within desirable limits.

Copper ion concentration is reported to be above desirable limit in one sample of formation water whereas in other samples including industrial effluents and surface water it is within the permissible limit. The presence of Cadmium above desirable limit is found in formation water at Karukkupet where the electroplating industries exist. Cadmium in surface water is also found above desirable limit to the extent of being toxic in Amulavayal drain.

Toxic surface water due to presence of Lead is recorded both in Korttalaiyar river and Amulavayal drain. It is also found in formation water samples collected at Korukkupet and Erukkancherri.

Presence of Iron and Manganese concentration exceeding the desirable limit is recorded in the formation waters as well as in surface water except west central part of the study area.

It is found that the quality of ground water as well as surface water in the up stream side of temporary check dam constructed across the Amulavayal drainage to arrest entry of back water is good. However, ground water and surface water in the down streamside of the above mentioned check dam are polluted.

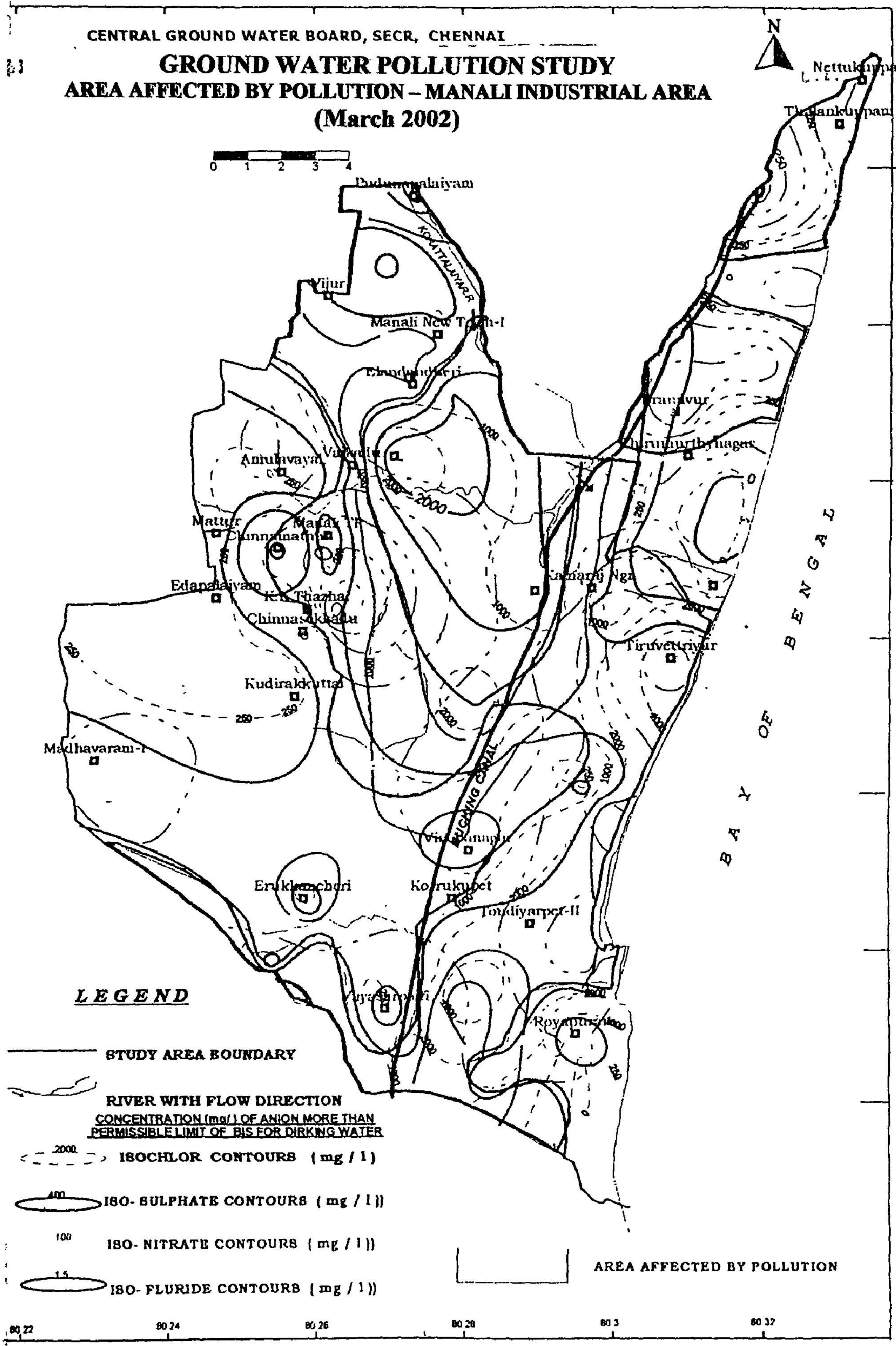
The studies have thus confirmed that surface water is polluted by industrial effluents, which in turn pollutes the ground water (CGWB, 2003).

CENTRAL GROUND WATER BOARD, SECR, CHENNAI

GROUND WATER POLLUTION STUDY

AREA AFFECTED BY POLLUTION – MANALI INDUSTRIAL AREA

(March 2002)



LEGEND

STUDY AREA BOUNDARY

RIVER WITH FLOW DIRECTION

CONCENTRATION (mg/l) OF ANION MORE THAN PERMISSIBLE LIMIT OF BIS FOR DIRKING WATER

2000 ISOCHLOR CONTOURS (mg / l)

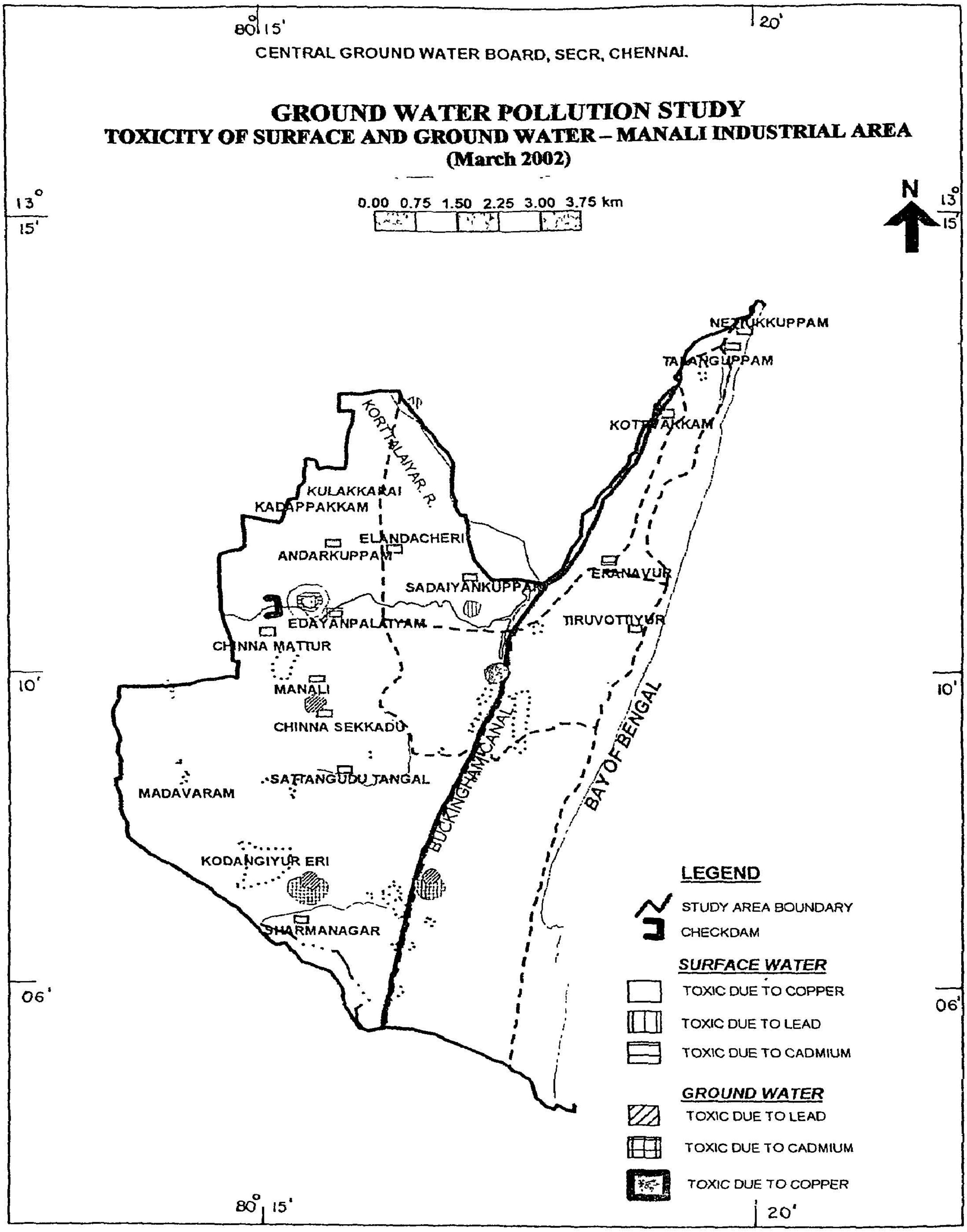
400 ISO- SULPHATE CONTOURS (mg / l))

100 ISO- NITRATE CONTOURS (mg / l))

1.5 ISO- FLURIDE CONTOURS (mg / l))

AREA AFFECTED BY POLLUTION

PLATE - 6.1.3



CENTRAL GROUND WATER BOARD, SECR, CHENNAI.

GROUND WATER POLLUTION STUDY
TOXICITY OF SURFACE AND GROUND WATER – MANALI INDUSTRIAL AREA
(March 2002)

6.2 GROUND WATER CONTAMINATION AND POLLUTANT MIGRATION IN THE TANNERY BELT, IN AND AROUND DINDIGUL, DINDIGUL DISTRICT

Tannery wastes pose a serious threat to the quality of ground water in several areas. There are a large number of Tanneries in the state and the waste water from the industry has caused considerable damage to water sources, affecting drinking water supply and irrigation.

6.2.1 BACKGROUND INFORMATION

Dindigul is one of the major industrial and commercial towns of Tamil Nadu and forms the headquarter of Dindigul district. It is one of the important tanning centres in Tamil Nadu. There are about 60 registered medium and small scale tanneries in clusters, which are located in and around Dindigul town. Drastic changes have taken place in the tanning process in recent years. The process of vegetable tanning, which was in vogue earlier has been replaced by the more recent chromium tanning. A large quantity of fresh water is being consumed for tanning. Due to lack of integration of environmental considerations in the development of this region, the fast growth of the tanning industry in this belt has resulted in a drastic change in the environment. The tanneries, which do not have effluent treatment plants discharge the untreated effluents laden with salts and other pollutants like chromium, lead etc. in large amounts indiscriminately into the open lands, pits, channels, tanks and in low-lying areas. Lagooning of tannery wastes, or spreading on land for evaporation, together with the solid wastes has led to the contamination of ground water, which is the only source for drinking water and irrigation. The ground water in large areas have become unsuitable for domestic and irrigation purposes due to contamination from these wastes.

The study was taken up by CGWB in collaboration with Department of Civil Engineering, Anna University, Chennai. An area of about 250 sq km covering Dindigul town and its environs, was taken up for intensive study under this project.

Drastic changes have taken place in the tanning process in the recent years.The process of vegetable tanning, which was in vogue earlier, has been replaced by the more recent chromium tanning during which a large quantity of fresh water is consumed for tanning. Due to lack of integration of environmental considerations in the development of this region, the fast growth of the tanning industries has resulted in a drastic change in the environment. The tanneries, which did not have effluent treatment plants discharged the untreated effluents laden with salts and other pollutants viz., chromium, lead etc., in large amounts indiscriminately in to the open lands, pits, channels, tanks and in low-lying areas for a long period. Chemicals used in tanning include lime, sodium carbonate, Sodium bicarbonate, common salt, Sodium sulphate, Chrome sulphate, fat liquors, vegetable oils and dyes. The quantity of total wastewater discharged for 100 kg of skins and hide processed varies from 3000 to 3200 litres. For every 10 tons of salted hides and skins processed, 2-3 tons of salt is removed and in addition another one ton of salt is removed, while pickling. Other major chemical constituents of the waste from tanning are Sulphide and Chromium. It is established that a single tannery can cause the pollution of ground water around the radius of 7 to 8 km.

(Bhaskaran et al., 1977). The discharge of untreated effluents was stopped in 1996 with the commissioning of a Common Effluent Treatment Plant in the area. However, ground water in the area still contains a considerable amount of pollutants discharged over the years. Further, the water discharged from the Common Effluent Treatment Plant is found to have TDS values in excess of permissible limits for domestic or agricultural uses, resulting in the continued quality deterioration of ground water.

Central Ground Water Board has taken up an R & D Scheme under Hydrology Project to study the spatial and temporal distribution of chemical constituents in the groundwater. Solute transport ` onceptu techniques have been employed to determine the extent of pollution and it's migration over time.

The main objectives of the project were;

1. Identification and onceptualizatio of recharge and discharge parameters of the groundwater regime and to establish their quantitative interrelationships.
2. Determination of various components of the effluents discharged from the tanneries.
3. Simulation of the system through numerical modeling to develop a management tool for ` onceptualization of the process of contamination and *pollutant migration.*

6.2.2 RESULTS OF THE STUDY

1. The area is underlain by granite gneiss and charnockites of Archean age (Plate-6.2.1).

2. The top soil extend down to 2 m, and is underlain by weathered residuum extending down to 25 m. The fractures extend down to a depth of 100 m (Plate-6.2.2 & 6.2.3).

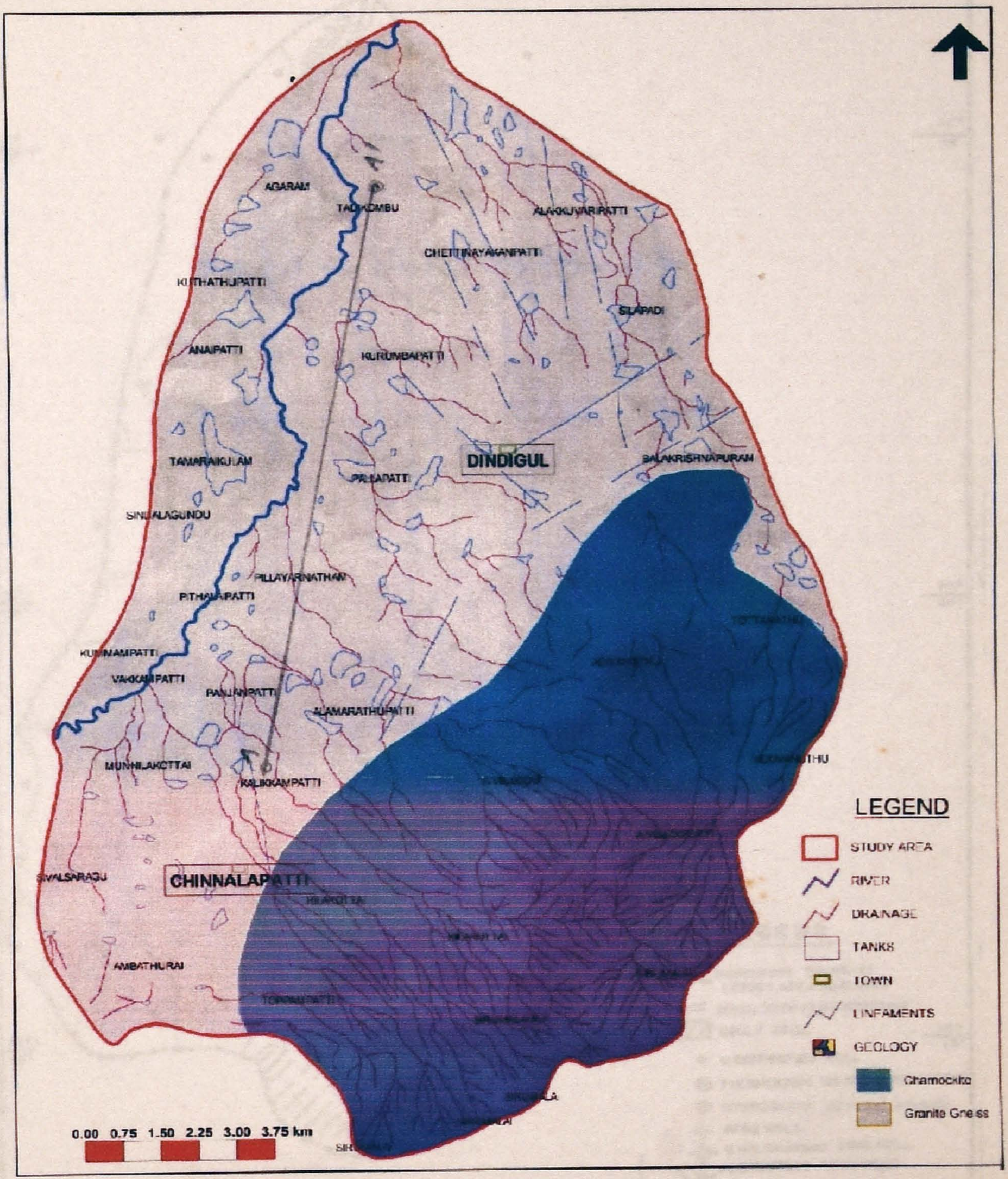
3. Groundwater occurs in phreatic condition in top weathered residuum and in semi confined to confined condition in fractured aquifer.

4. In the weathered zone, the ground water flow direction, in general is towards south west, north and north west in the southern part, southwest and west in the central part and north and northwest in the northern part of the area. In general, the flow is towards the Kodavanar river.

5. The contamination of groundwater due to the discharge of pollutants is manifested as increase in chloride and chromium concentrations in the formation water. Chloride concentration in groundwater samples has been identified for pollutant migration study.

6. Areas characterised by abnormally high values of Chloride have been demarcated and such areas were found, in general, around the tanneries and also along the flow path of polluted groundwater. Chloride values are often more than 1000 mg/l in the central portion adjoining the tanneries with a maximum value of 9000 mg/l (west of Dindigul

GROUND WATER CONTAMINATION AND POLLUTANT MIGRATION IN THE TANNERY BELT – DINDIGUL DISTRICT - GEOLOGY



GROUND WATER CONTAMINATION AND POLLUTANT MIGRATION IN THE TANNERY BELT IN AND AROUND DINDIGUL, DINDIGUL DISTRICT, TAMIL NADU

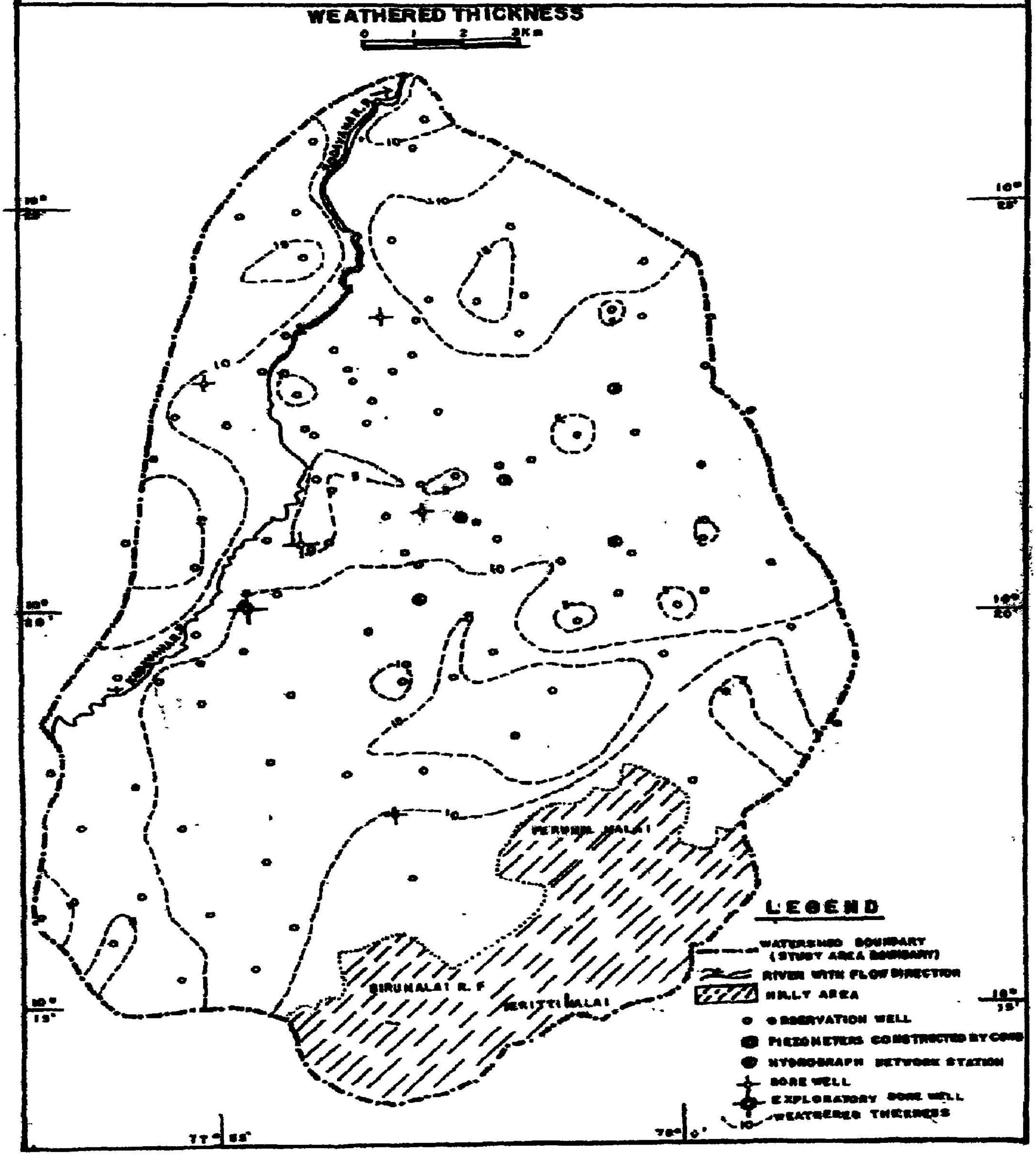
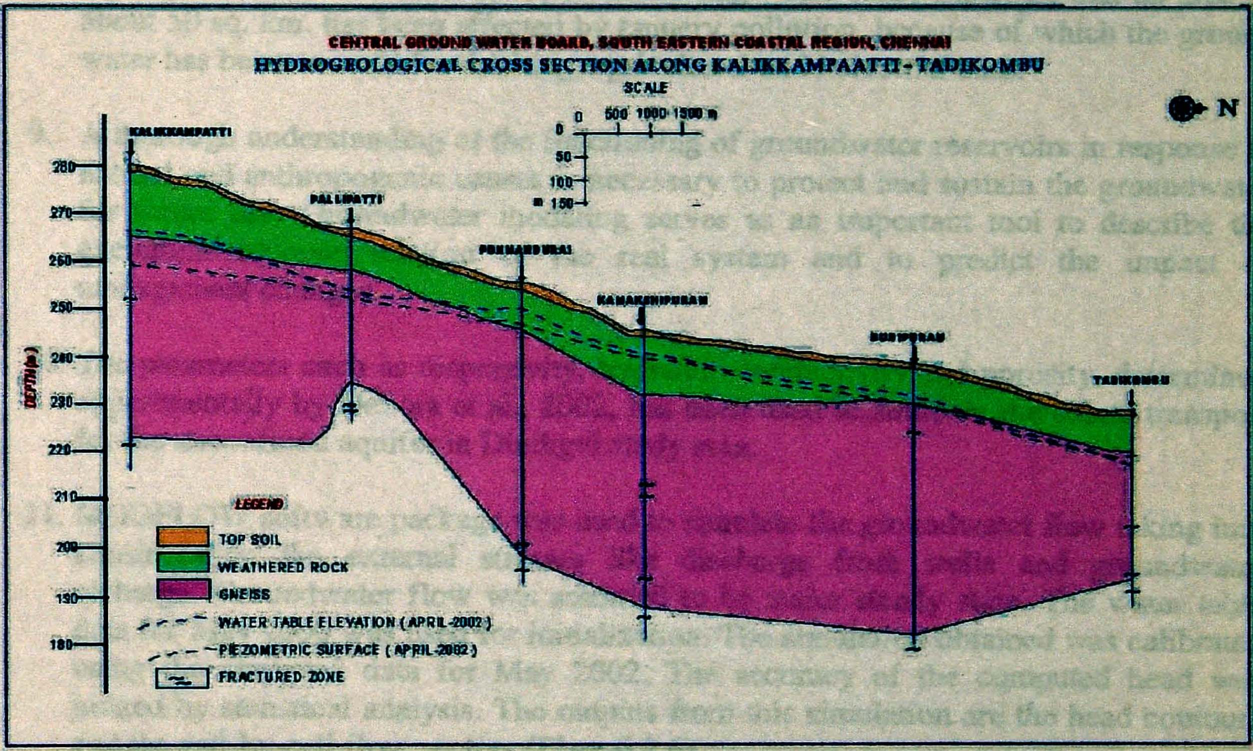


Plate-6.2.3


CENTRAL GROUND WATER BOARD, SOUTH EASTERN COASTAL REGION, CHENNAI
HYDROGEOLOGICAL CROSS SECTION ALONG KALIKKAMPAATTI - TADIKOMBU
SCALE
0 500 1000 1500 m
0
50
100
m 150
N
KALIKKAMPATTI
PALLIPATTI
PONNANDURAI
KAMAKSHIPURAM
BUDIPURAM
TADIKOMBU
DEPTH(m)
280
270
260
250
240
230
220
210
200
190
180
LEGEND
TOP SOIL
WEATHERED ROCK
GNEISS
WATER TABLE ELEVATION (APRIL-2002)
PIEZOMETRIC SURFACE (APRIL-2002)
FRACTURED ZONE

Town). Further, in the north eastern part of the study area, where tanneries used to exist in the past and have been closed down about 5 years back, Chloride values are found to be in the range of 500 - 2000 mg/l (Plate-6.2.4).

7. The concentration of Total Chromium in ground water from the area ranges from 0.001 to 0.194 mg/l (Plate-6.2.5).(Desirable limit – 0.05 mg/lit.)

8. The extent of pollution and groundwater flow direction have been identified on the basis of field studies and analysis of ground water samples. The same were used as input parameters for solute transport modelling. The study indicates that an area of about 50 sq. km. has been affected by tannery pollution, because of which the ground water has become unfit for drinking, agricultural and industrial uses.

9. A thorough understanding of the functioning of groundwater reservoirs in response to natural and anthropogenic causes is necessary to protect and sustain the groundwater for future use. Groundwater modeling serves as an important tool to describe the excitation-response relation of the real system and to predict the impact of management changes.

10. The parameters such as dispersivity, hydraulic conductivity and porosity, determined experimentally by Debora et al., 2002, has been used to simulate the solute transport for the unconfined aquifer in Dindigul study area.

11. MODFLOW software package was used to simulate the groundwater flow taking into consideration the external stresses like discharge from wells and groundwater recharge. Groundwater flow was assumed to be under steady state. The water table data for May 2000 was used for initialization. The simulation obtained was calibrated using the observed data for May 2002. The accuracy of the computed head was judged by statistical analysis. The outputs from this simulation are the head contours and the cell-by-cell flow vectors (Plate-6.2.6).

12. MT3D software was used to simulate the contaminant transport due to advection, dispersion and source/sink mixing and to predict the concentration in the future with respect to time and space (Plate-6.2.7). The chloride concentration data for May 2000 were used for initialization. The simulation was calibrated using the observed data for May 2002. The accuracy of the computed concentration was judged by statistical analysis. Simulation was done to predict the contaminant concentration after a period of 5years, with respect to time and space (Plate-6.2.8).

13. The studies carried out in the area indicate that the Common Effluent Treatment Plant has not been effective in reducing TDS to permissible limits for domestic use. The disposal pond (Sengulam tank) into which the effluents are let out, hence, acts as a point source of pollution. Additional steps in effluent treatment such as reverse osmosis, which helps in removal of salts, may be introduced. The added advantage of reverse osmosis is that the treated effluent is almost as good as fresh water.

Plate-6.2.4

GROUND WATER CONTAMINATION AND POLLUTANT MIGRATION IN THE TANNERY BELT- DINDIGUL DISTRICT -ISOCHLOR

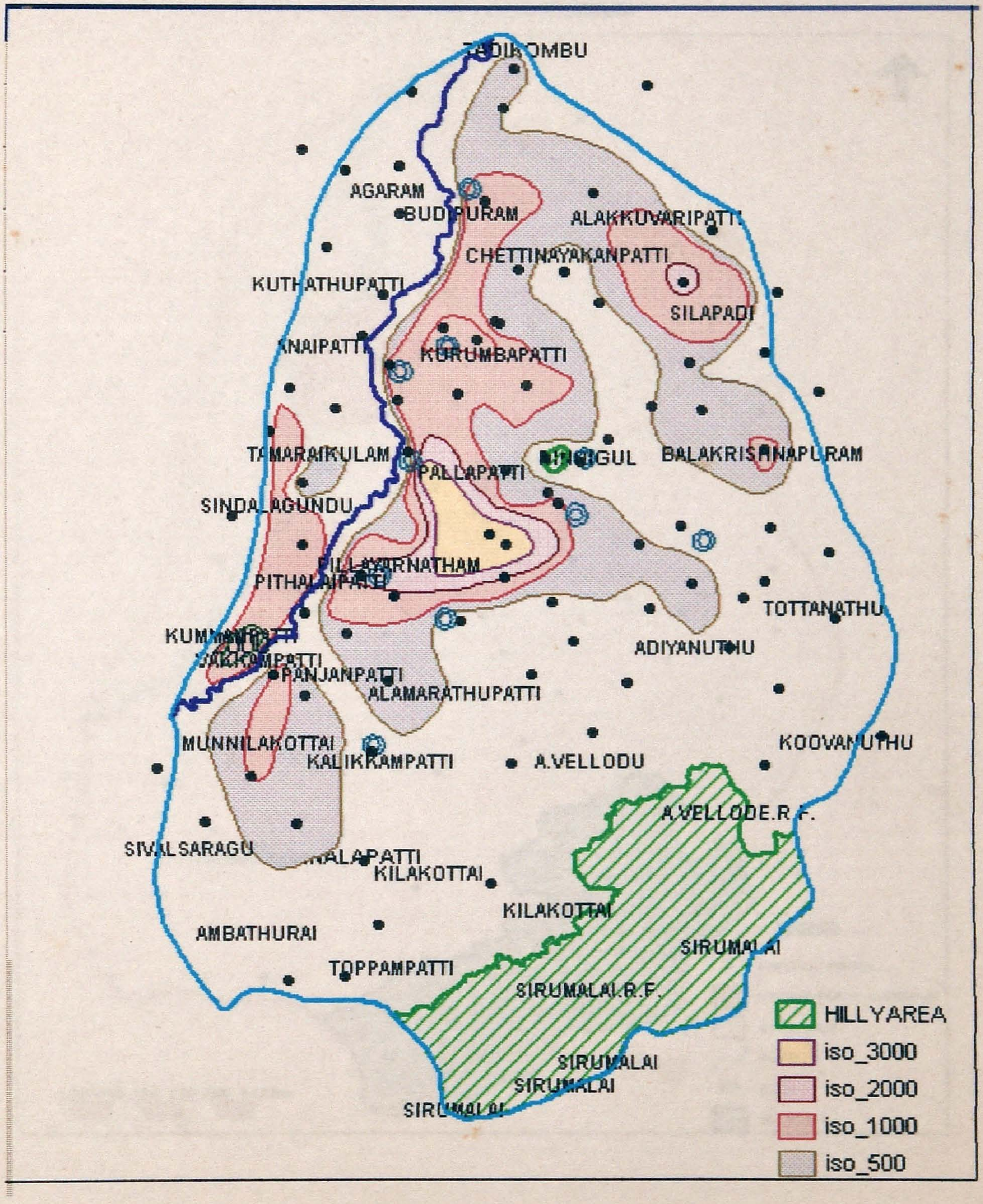


Plate-6.2.5

GROUND WATER CONTAMINATION AND POLLUTANT MIGRATION IN THE TANNERY BELT IN AND AROUND DINDIGUL, DINDIGUL DISTRICT, TAMIL NADU

DISTRIBUTION OF CHROMIUM

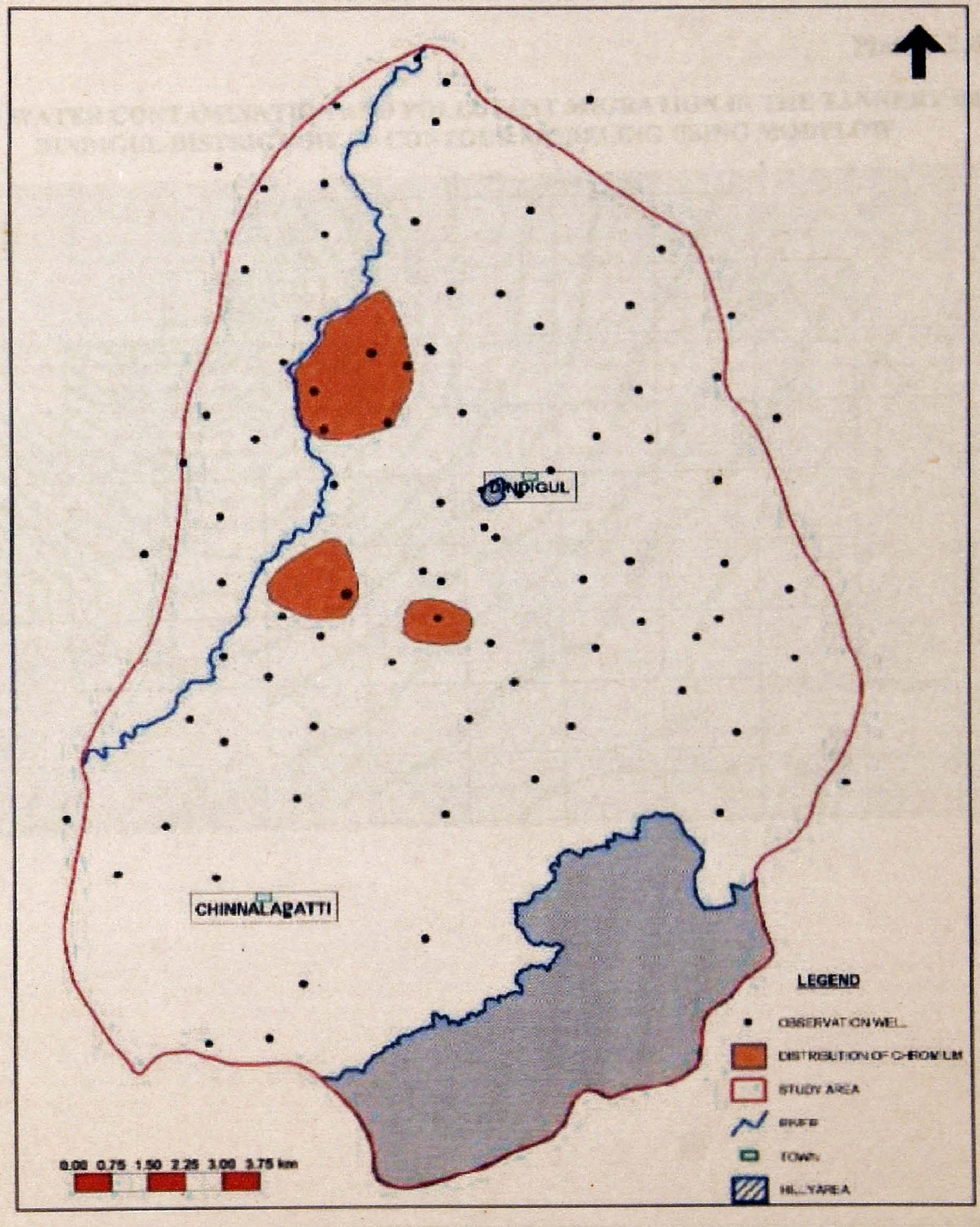


Plate 6.2.6

GROUND WATER CONTAMINATION AND POLLUTANT MIGRATION IN THE TANNERY BELT – DINDIGUL DISTRICT- HEAD CONTOUR MODELING USING MODFLOW

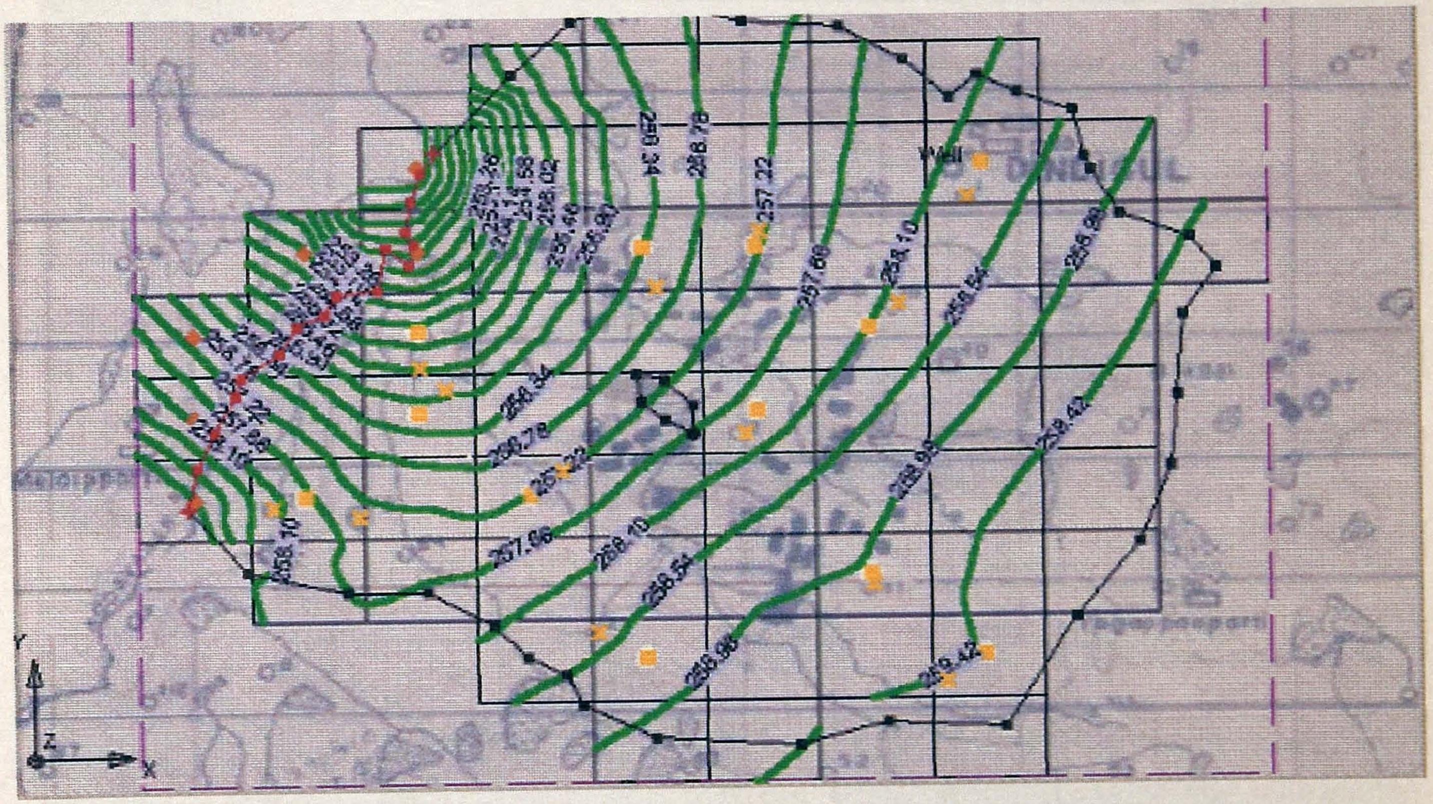


Plate-6.2.7

GROUND WATER CONTAMINATION AND POLLUTANT MIGRATION IN THE TANNERY BELT – DINDIGUL DISTRICT – PREDICTED FLOW VECTORS

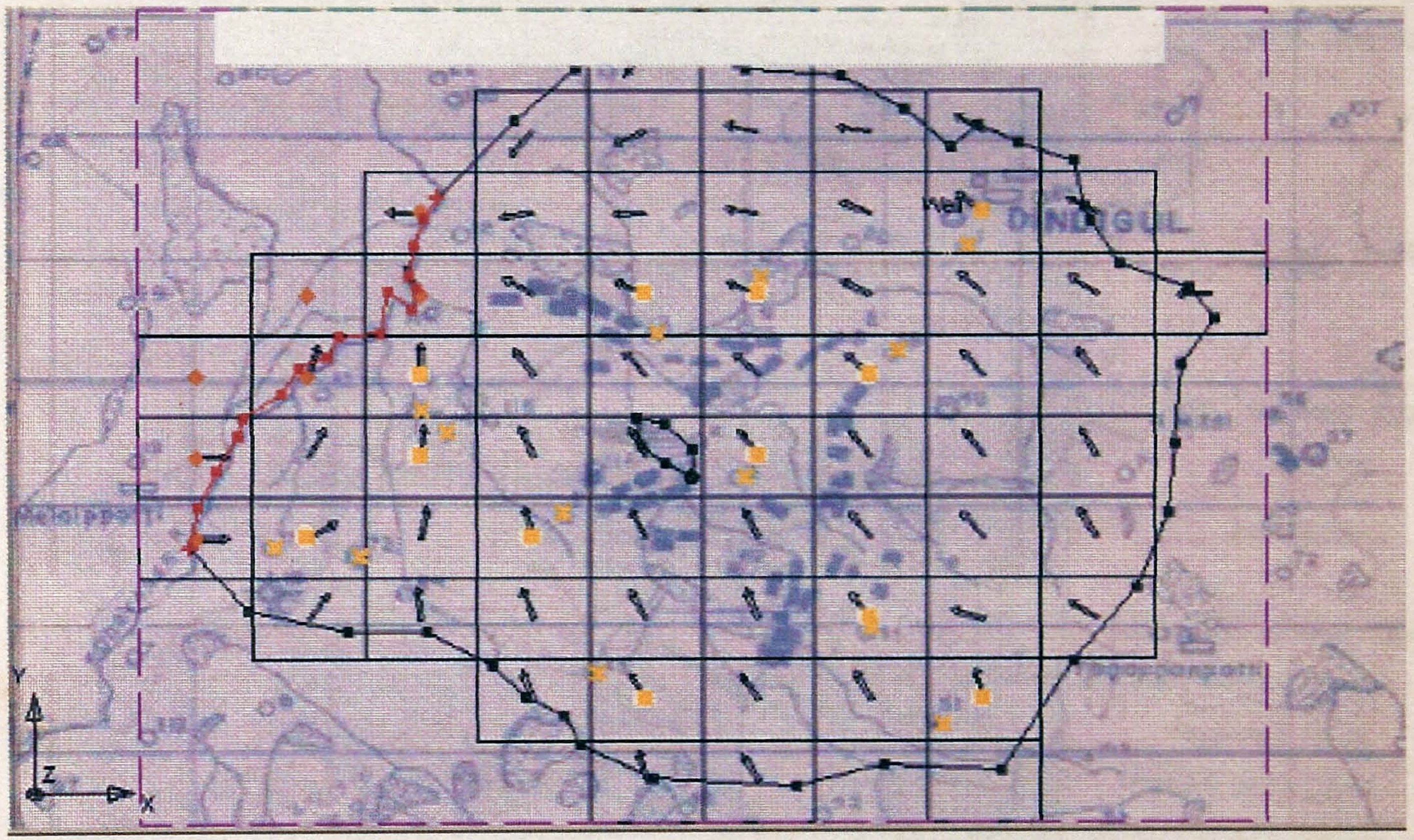
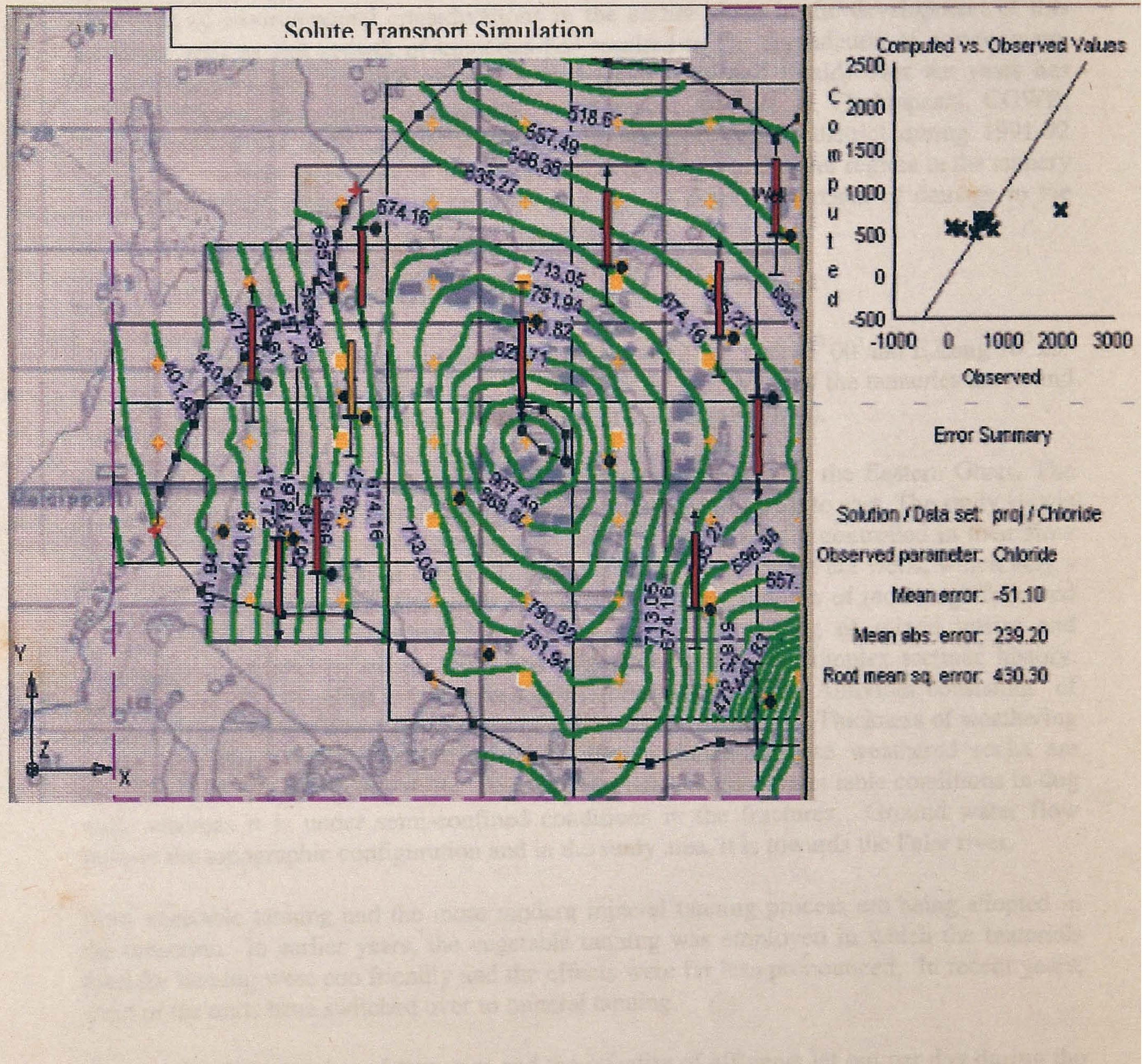


Plate-6.2.8

GROUND WATER CONTAMINATION AND POLLUTANT MIGRATION IN THE TANNERY BELT – DINDIGUL DISTRICT



Error Summary

Solution / Data set: proj / Chloride
Observed parameter: Chloride
Mean error: -51.10
Mean abs. error: 239.20
Root mean sq. error: 430.30

6.3 GROUND WATER POLLUTION IN VELLORE DISTRICT

Leather tanning is one of the established industries and is more than a century old in Vellore district. Both vegetable tanning and mineral tanning processes are adopted. Lack of integration of environmental considerations in the earlier years in the development of this region, as well as fast growth of tanneries has resulted in the degradation of environment. The discharge of the untreated tannery wastes (both solid and liquid) over the years has severally affected the surface and ground water resources. Sh. R. Chakrapaani, CGWB, Chennai carried out hydrogeological surveys in parts of Vellore district during 1991-92 &1992-93, to assess the impact of tannery effluents on the ground water regime in the tannery belt of Ranippettai region and its environs and also to assess the extent of damage to the ground water and for remedial measures thereof.

6.3.1. BACKGROUND INFORMATION

The study area of about 300 sq .km lies between N.Lat $12^0$50' and 13^0 00'and E.Long 70^0 25' and falls in Survey of India Topographical Sheet No: 57 P/5. Most of the tanneries are in and around Ranippettai, which is about 110 km West of Chennai (Madras).

The western part of the study area is flanked by the hill ranges of the Eastern Ghats. The plains are characterized by undulating topography sloping from west to east. The study area is drained by the Palar river and its tributaries, which are structurally controlled in their flow traverses and are ephemeral in nature. The chief sources of irrigation are wells, which play a significant role in irrigation. The study area is underlain by alluvium of recent age followed by crystalline metamorphic rocks of Archaean age, comprising of mixed gneiss and charnockites, intruded by quartz veins and pegmatites and has a complex tectonic history. Two or three sets of joints are observed in the crystalline rocks. Alluvium consisting of sands and clays occurs along the courses of Palar and its tributaries. Thickness of weathering in the crystalline rocks ranges upto 15m. The aquifers in these weathered rocks are extensively developed by dug wells. Groundwater occurs under water table conditions in dug wells whereas it is under semi-confined conditions in the fractures. Ground water flow follows the topographic configuration and in the study area, it is towards the Palar river.

Both vegetable tanning and the more modern mineral tanning process are being adopted in the tanneries. In earlier years, the vegetable tanning was employed in which the materials used for tanning were eco friendly and the effects were far less pronounced. In recent years, most of the units have switched over to mineral tanning.

The details of the number of tanneries and the quantity of effluents let out per day during the period of survey are furnished in Table –6.3.1.

Table –6.3.1Number of tanneries and the quantity of effluents let out per day in Vellore district

No. of Tanneries	Processing Capacity of leather (Kg/ day)	Quantity of effluents let out per day (Million litres)	Chrome tanning industries	Chrome tanned leather processing capacity (Kg day)	Chromium present in effluents (tons day)
1	2	3	4	5	6
108	1,89,000	18,90	75	1,32,300	343.98

(Source: Chakrapaani-1998)

P.S. 2.6 gms of chromium is being used for 1 Kg of leather processing.

The quality of ground water in phreatic aquifers was studied through sampling from dug wells in and around the area affected by the tannery effluents. A few samples were collected from the bore wells also. The water samples were subjected to analysis for determining the various parameters and also the levels of trace elements like chromium, lead, manganese etc.

The color of water in most of the wells affected by the tannery effluents varies between bright brown to dark brown with a pungent odour. It is from sour to saltish taste.

In the upper reaches of the Palar river as well as in the recharge areas (i.e.) where the tanneries didn't exist at the time of study, the ground water is colorless, odourless and sweet.

The waters are generally alkaline with pH values ranging from 7 to 8.5 but in a few cases it was less than 7.

The electrical conductivity of the ground water in the study are ranged from 220 to 9300 µs / cm at 25^0 C, the maximum being at Devadanam, which is about 3 km South – east of Ranipettai. EC values exceeding 500 µs / cm in ground water have been observed at Ranipettai, Vannivedu, Devadanam and Kil Minnal. Ground water with low salinity values of less than 1000 µs / cm at 25^0C occurs in the recharge areas as well as in the unaffected areas.

Chlorides in ground water have essentially the same distribution as that of electrical conductance in the study area.

The ground water, in general, is hard to very hard with a total hardness as $CaCO_3$ varying between 215 and 2640 mg/l.

The water from most of the wells affected by the tannery effluents are severely polluted with sodium salts above permissible limits. It has also been observed that these waters contain a good amount of Ca and Mg inherited mainly from tanneries where lime is used in huge quantities for loosening of hair.

The analytical data indicate that the Sodium Adsorption Ratio (SAR) which is a measure of sodium hazard in the water samples analysed is found to range between 0.7 to 15.9 in Ranipettai region. Most of the water samples fall in categories of C_4 S_3 to C_4 S_4 thereby indicating high salinity and sodium hazard and found unsuitable for irrigation uses.

The impact of tannery chemicals on ground water with special reference to trace elements chromium, lead, manganese, iron, zinc etc. was studied. The ranges for the said trace elements in ground water are furnished in Table –6.3.2.

Table –6.3.2 Range of Trace Elements in Ground Water of the Study Area
(Period : March 1992)

Sl. No	*Name of the trace element*	*Ranipettai Region (mg/l)*	*Maximum Permissible limits(mg/l)*
1	Cadmium	0.01 – 0.04	0.01
2	Cobalt	0.03 – 0.14	
3	Chromium	0.00 – 0.17	0.05
4	Copper	0.00 – 0.03	1.00
5	Iron	0.00 – 0.68	0.03
6	Manganese	0.00 – 6.34	0.05
7	Nickel	0.01 – 0.17	-
8	Lead	0.02 – 0.28	0.05
9	Zinc	0.00 – 0.06	5.00

(Chakrapani, 1998)

It has been observed that iron and manganese are uniformly present in relatively high concentrations and interestingly the level of manganese was often high (i.e.) 6.34 mg/l in a dug well affected by the tannery effluents at Kil Minnal, which is about 9 Km WNW of Ranipettai. Similarly, lead and chromium levels are uniformly high and there exist a correlation between the concentrations of lead and chromium. The distribution of chromium in ground water has been shown in Plate-6.3.1. Levels of chromium ranged upto 0.10 mg/l though a high value of 0.17 mg/l has been recorded at Sakkiramallur, which is about 12 km. ESE of Ranipettai. Thus may be due to the large quantities of lead chromate used in tanning. The percentages of water samples in which the levels Cr., Mn., Fe., Pb and Cd exceed the maximum permissible limits for domestic uses in Ranippettai region are furnished in Table – 6.3.3.

PLATE - 6.3.1

HYDROGEOLOGY

RANIPET REGION, VELLORE DISTRICT.

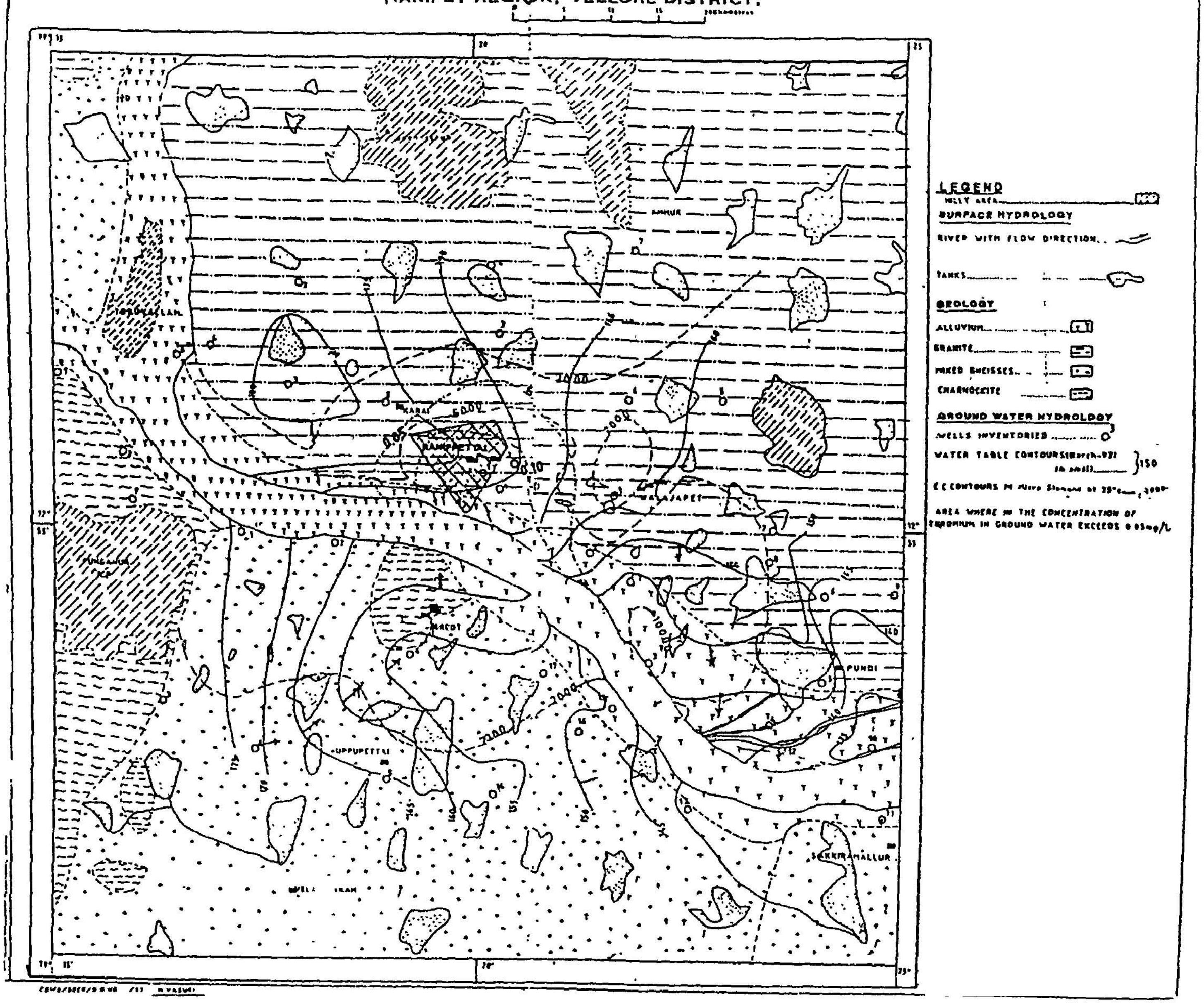


Table –6.3.3 Statement showing the percentage of Water Samples having Trace Elements in Excess of Permissible Limits

No of water samples Analysed	Chromium		Manganese		Iron		Lead		Cadmium	
	No.	%	No.	%	No.	%	No.	%	No.	%
18	4	22	13	72	6	33	11	61	12	67

It is observed from the table that the levels of Pb are in excess of the permissible limits in 61 percent of the water samples analysed followed by Cd, Mn and Fe. Though the presence of chromium has been noticed uniformly, it is within permissible limits in about 80 percent of the samples analysed. The analytical data of the water samples collected from a shallow tube well of 12 to 15 m depth at Arcot tapping the Palar alluvium shows that the concentrations of Cd, Fe and Mn are much higher than the permissible limits. The concentrations of Fe, Mn and Pb are much higher than the permissible limits in case of a tube well of about 50 m depth at K.Visharam tapping the waters in the weathered and partly jointed mixed gneisses.

6.3.2 RESULTS OF THE STUDY

The untreated effluents from the tanneries discharged indiscriminately over the years have reached the ground water through percolation and have polluted the ground water resources in the study area adaversely affecting on the humans, livestock and plant health. The situation has reached alarming proportions in the absence of a scientific environment management plan.

A noticeable change on the characteristics of the soil, its fertility and productivity as well as a marked deterioration in the quality of ground water has been observed, thereby rendering thousands of hectares of fertile lands sterile.

Ground water in the close vicinity of several tanneries are affected to varying degrees. The ground water at all levels has been severally polluted, thereby rendering it unfit for all uses. A sizeable reduction to the tune of about 40 percent in agricultural produce has occurred. The effects of ground water pollution are seen in the stunted growth, poor germination, staining, leaf burn, poor quality of fruits, grains etc.

The studies have revealed that the quality of ground water in the major part of the study area has been highly affected and found unfit for all purposes. Higher concentration of chromium in ground water has been observed in an area of about 30 sq. km. in and around Ranipettai. Similar is the case around Muppaduvetti, which is about 5 km South-East of Ranipettai and also at Sakkiramallur.

Thus the entire region over a length 20 km especially the water sources in some of the villages viz., Vannivedu and Devadanam have been totally endangered requiring urgent remedial measures.

The Palar river, which is main life line feeding many towns and industries including the tanneries, with its aquifers in the study area became " Pazhar" a river of wastes. Owing to the inadequate flows in the Palar river, dispersal of hazardous waste is very ineffective.

To conclude, the solid and liquid wastes from the tanneries have caused irreparable damages the water sources affecting the local populace and to some extent to the tanneries themselves. The studies have revealed that the Ranipettai region is an endangered area and warrants strong measures from Government and Non-Government agencies to arrest the deterioration of water quality and prevention of migration of pollutants to new areas and enforcing environmentally sustainable practice by tanneries.

6.4 GROUND WATER POLLUTIONS IN UPPER PALAR BASIN

Ground water pollution studies in Upper Palar Basin, Tamil Nadu were carried out in an area of about 300 sq. km in Ranipet, Ambur-Pernampattu – Vaniyambadi areas in Vellore district during AAP 1999 – 2000 by Shri D.M. Rama Rao, Scientist – D.

6.4.1 BACK GROUND INFORMATION

Ranipet zone lies between 12^0 53' and 12^0 57' North Latitude, 78^0 35' and 78^0 45' East Longitude falling in Survey of India Toposheet No: 57 P/5. The Pernampattu Ambur-Vaniyambadi zone lies between 12^0 39' and 12^0 57' North Latitude, 78^0 35' and 78^0 45' East Longitude falling in Survey of India toposheet Nos. 57 L/9 and 57 L/10. A total number of 117 wells were inventoried. 164 water samples were collected of which 56 Nos. are treated with 2ml of 1:1 HNO_3 at the time of collection for determination of trace element.

The tanneries in this district are in four clusters around the towns namely Ranipet, Ambur and Vaniyambadi, which are located on the banks of Palar river and Pernampattu, which is on the banks of Malattar river, a tributary of Palar river. Both vegetable and mineral tanning processes are adopted by these tanneries and in recent years most of the units have switched over to mineral tanning. The untreated effluents, which are indiscriminately discharged from the tanneries, have rendered the ground water highly polluted.

Rolling topography is a characteristic feature in Vaniyambadi – Ambur – Pernambut zone and is surrounded by the hill ranges of Eastern Ghats on both sides. The Ranipet zone is characterized by a gently undulating topography and is surrounded by the hill ranges on the northern side.

The area is drained by the Palar river and its tributaries, which are ephemeral in nature and serve for drinking water supply schemes to the villages and towns.

The study area is underlain by the Recent alluvium followed by the crystalline rocks of Archaean age. The alluvium comprising sands and clays in varying proportions is confined to the river courses only. The thickness of the alluvial deposits ranges upto 15 m. The crystalline rocks comprise the mixed gneisses and charnockites with intrusions of pegmatites. These rocks are highly weathered, fractured and jointed. The thickness of weathering as observed from the well sections ranges up to 15 mbgl.

About 117 open wells and a few tube wells used for drinking, irrigation and industrial purposes were canvassed during the course of survey and the hydrogeological data for the same were collected. The depth of the open wells in the study area ranged from 5 to 23 mbgl and the depth to water in them varied from less than a meter to 18 m.

Water samples from the canvassed wells affected by the tannery pollution and also from the unaffected areas were collected during the course of survey for detailed chemical studies including the determination of trace metals. A total number of 164 water samples were collected of which 56 Nos were treated with 2 ml of 1:1 HNO_3 at the time of collection for determination of trace elements. 108 water samples were analysed for 12 parameters, in the Chemical Laboratory of SECR, Chennai.

6.4.2 RESULTS OF THE STUDY

The analysis of E.C. values showed that in 9 % of the samples the E.C.value is less than 1000 Microsiemens / cm at 25^0 C and 41 % of the samples are in the range of 1000 to 3000, about 33 % are in the range of 3000 to 6000, about 11 % are in the range 6000 to 9000 and 6% are in the range of above 9000 (varying from 9120 to 22,900) Microsiemens /Cm at 25^0 C.

The analysis of total hardness as Ca CO_3 showed that in 34% of the samples it is less than 500 mg/l, and 43% of the samples are in the range of 500 – 1000, about 17% are in the range of 1000 to 2000, and 6% are in the range of > 2000 mg/l.

The analysis of chloride showed that in 27 % of the samples it is less than 250 mg/l and 22% of the samples are in the range of 250 to 500, 22% are in the range of 500 to 1000 and 29% are above 1000 mg/l.

The analysis of sulphate showed that in 58% of the samples it is less than 200 mg/l and 37 % of the samples are in the range of 200 to 500, 4% are in the range of 500 to 1000 and 1 % are above 1000 mg/l.

The analysis of Nitrate showed that in 88% of the samples it is less than 45 mg/l and 9% of the samples in the range of 45 to 100 and 3% are above 100 mg/l. The analysis of sodium showed that in 31% of the samples it is less than 200 mg/l and 43 of the samples are in the range of 200 to 500, 20% are into range of 500 to 1000 and 6% are above 1000 mg/l.

The following recommendations / suggestions are given for the control of ground water pollution and also for a sustainable environment.

⇒Pollution control technologies available with CLRI should be adopted by the tanneries for minimizing the use of salt and chromium besides recycling inputs. This will minimize the pollution of ground water.

⇒Concrete based lagoons above ground level be constructed in sufficient numbers to store all the effluents discharged, with provision for covers to prevent rain water accumulation and overflowing. This could prevent seepage to a considerable extent.

⇒The effluent treatment plants are to be installed on scientific lines, taking into account the volume of effluents to be disposed and in such a way that the treated effluents can be used by tanneries. Waste water treatment practices be adopted in the industry itself, which will help in conservation of fresh water and prevention of further pollution.

⇒The indiscriminate discharge of untreated effluents mixed with chemical and solid wastes in the open lands, rivers, channels and tanks should be stopped immediately by enforcing the regulatory measures strictly.

⇒Ground water pollution can be decreased by manipulation of subsurface gradient by injection or withdrawal of waters. Various well systems include well point systems, deep well systems, pressure ridge systems, combined system and immiscible contaminant recovery systems. Any one of these systems can be implemented on pilot basis. The basic objectives in these systems is plume management, which is achieved by designing well systems to control movement of water phase and contaminants directly.

⇒Highly toxic pollutants in ground water can be isolated by use of impermeable barriers such as steel sheet piles, grout curtains and slurry walls.

⇒The quality of both surface water and ground water sources be monitored continuously.

⇒The handling of waste products and polluting effluents must receive the same attention as given to production. The tanneries should not view at them as foreign to them.

⇒Licences should be issued to the new tanneries who submit an environment plan and permission for setting up the tanneries in the recharge areas should not be accorded at any cost.

⇒Environmental impact assessment and audit should be carried out periodically by monitoring committees comprising the technocrats, districts administrators, voluntary agencies, industrialists, and representatives from the local villages to implement the pollution control measures for protecting the environment from further damage as well as monitoring of the state of ambient environment near the tanneries.

⇒Biological reclamation plans involving raising of specific types of salt tolerant trees and hedges to hold the soil in the affected areas can be adopted.

6.5 GROUND WATER POLLUTION IN TIRUPPUR AND ITS ENVIRONS, IN COIMBATORE AND ERODE DISTRICTS

6.5.1 BACKGOUND INFORMATION

Tiruppur Block, Coimbatore district and adjoining polluted area in Erode district, Tamil Nadu having a geographical area of 363 sq.km, lies between North Latitudes 11^{0}03' to 11^{0}12' and East Longitudes 77^{0}16' to 77^{0}34' in the Survey of India Topo sheet Nos. 58 E/4 and 58 E/8 has been taken up for the study during 2001-02. It is located in the north-eastern part of Coimbatore district. Tiruppur block is bounded on north and east by Uthukuli and Kangeyam blocks of Erode district on west by Sulur and Avinashi blocks of Coimbatore district and south by Palladam and Pongalur blocks of Coimbatore district.

The area is characterized by an undulating topography with a gentle slope from west to east. The area is drained by the Noyil and Nallar rivers, which are the tributaries of river Cauvery and are ephemeral in nature. Chinnakarai Nalla is the tributary of river Noyil and it flows from south to north and confluences with the Noyil at Tiruppur town itself. The river has a moderate to good flow for a short period during north-east and south-west monsoons. The river supplies water to several tanks located in and around Coimbatore City. As the river waster has been diverted to various tanks it hardly has any flow downstream of the river Noyil.

Across the river Noyil a major check dam has been constructed for irrigation at Orattupalayam, about 30 km down stream of Tiruppur in January, 1992. The dam has caused the stagnation of effluents and sewage water, resulting in the contamination of dug wells in the adjoining areas and making them unsuitable for drinking and irrigation purpose.

A wide range of high-grade metamorphic rocks of the peninsular gneissic complex underlies the area. The rocks are extensively weathered and the thickness of weathering ranged from 0.25 to 16.28 m bgl.

Dug wells, dug-cum-bore wells and bore wells are the major ground water extraction structures in the area. Ground water occurs under phreatic conditions in the weathered zone and semi-confined conditions in the deeper fracture zones. The depth of the dug wells range from 4.40 m to 34.8 mbgl and the depth to water level in them ranged between 0.78 m to 32.00 m bgl.

Tiruppur is famous for knitted fabrics. About 90% knitted fabric export of the country is from Tiruppur. The knitting industry comprises bleaching, dyeing, printing, sizing, de-sizing and finishing processes.

Textile bleaching and dyeing units consume a large quantity of water and generates almost equal quantity of waste water during the process. The typical water usage varies from 20 to 200 lit/kg of product depending on the type of bleaching and dyeing operation and depth of shades used.

Effluents from the bleaching and dyeing units contain a part of chemicals used during Dyeing and Bleaching processes. Bleaching industry uses chemicals such as caustic soda, hydrochloric acid, sodium sulphates, soap oil, hydrochloride, peroxides etc. Dying industry uses various types of dyes, sodium chloride, fixing agents, detergents, mineral acids etc.

The effluents, as a result, have high total dissolved solids (TDS) and intense colour caused by the dyes. Typical characteristics of the effluents in comparison with the corresponding tolerance limits prescribed by TNPCB for effluents disposed into inland water bodies is given in Table-6.5.1. The waste generation rate and waste characteristics vary widely depending on the types of bleaching process and nature of dyeing. The high TDS of the effluent will increase the salinity of water bodies. The coloured effluent will impart colour to the water making it aesthetically unacceptable. In addition, some of the dyestuffs carrying colour contain heavy metals and suspected carcinogens. Retardation of high penetration and photosynthetic activities may affect aquatic life..

Table-6.5.1 Tolerance limits for Bleaching and Dyeing Effluents

Parameters	*Bleaching effluents*	*Dyeing Effluents*	*Tolerance limits for inland surface water disposal (IS:2490-1982)*
pH	*8 – 9.5*	*6.9 – 9.5*	*5.5 – 9.0*
BOD (mg/l)	*150 – 180*	*300 - 400*	*Less than 30 mg/l*
COD (mg/l)	*250 – 300*	*650 - 750*	*Less than 250 mg/l*
SS (mg/l)	*130 – 150*	*300 – 400*	*Less than 100 mg/l*
TDS (mg/l)	*1600 – 1800*	*8000 – 11000*	*Less than 2100 mg/l*
Colour	*Whitish*	*Intense colour*	*Not visible to naked eye and shall not reappear on disposal.*

(Source: Tamil Nadu Pollution Control Board)

Tiruppur Municipality collects its solid waste and dumps it in 6 abandoned charnockites quarries located in and around Tiruppur. The abandoned quarries are (1) P.N.Road Quarry (2) Moscow Nagar Quarry (3) M.S.Nagar Quarry (4) Meltangadu Quarry (5) Alangadu Quarry and (6) Velliankadu Quarry.

The estimated solid waste generation is of the order of 100 tones per day. Tiruppur Municipality is floating a scheme for solid waste disposal along with private participation on build operate and transfer basis. It is proposed to collect the solid waste and to segregate it into biodegradable waste and non-biodegradable waste. The biodegradable waste will be turned into fertilizer after composting for 60 days. The non-biodegradable waste will be compacted for recycling. The liquid waste is to be let out into the river Noyil.

Across the river Noyil a dam, 2.29 km long was constructed at Orattu Palayam in 1990. The registered ayacut areas in Erode and Karur districts were 500 acres and 9875 acres respectively.

Presently the Orattu Palayam dam is used for storing effluents collected by river Noyil and Nallar River. The Sarkar Periyapalayam and Otur tanks are also linked to river Noyil and finally stored in Orattu Palayam Dam. It has been opened for irrigation only once since its commissioning and closed due to objection from the farmers in the down stream side .

For a detailed study of hydrochemical characteristics of ground water 87 Key wells were established. The water samples from 86 dug wells and 2 bore wells were collected and analysed.

Ground Water samples were collected for the analysis of major ions, trace metals and organic matter separately with suitable preservation techniques laid down in the standard analytical procedures. Based upon the field observations, 86 water samples were collected for analysis major ions, 31 samples for heavy metals and 47 samples for determining organic matter in terms of BOD and COD.

6.5.2 RESULTS OF THE STUDY

The pH of ground water in the area ranges from 6.97 to 8.40. Except one sample at Muruganapuram, all the other samples have pH above 7.00, indicating that the ground water is alkaline.

The ground water of the area is highly mineralized due to the discharge of effluents in most of the places. Wells located on the banks of Noyil River are severely contaminated. The EC ranges from 335 to 19390 µs /cm at 25°C. Amount 85 samples, 8 samples show EC below 1000 ųs/cm at 25°C, 15 samples have EC 1000 – 2000 ųs/cm at 25°C, 29 samples have EC ranging from 2001 – 4000 ųs/cm at 25°C, 27 samples have EC more than 4000 to 10,000 ųs/cm at 25°C and 7 samples have EC more than 10,000 µs/cm at 25°C. The maximum value of 19390 µs/cm is recorded at Mannur. Most of wells located nearby the bank of river Noyil are highly mineralized due to the seepage of untreated effluents, rendering the water unfit for domestic and agricultural purposes.

Calcium and Magnesium ions are the major contributors to hardness in ground water. The ground water is found to be excessively hard in all the contaminated areas. In the uncontaminated area, calcium is the dominant constituent indicating the natural evolution of ground water. But in most of the contaminated areas Calcium and Magnesium are found to be more or less equal and in some cases magnesium exceeds calcium. The hardness of ground water in the area ranges from 115 mg/l to 7600 mg/l as Ca CO_3 From the field observation it is found that due to excessive hardness the water becomes unfit for domestic and agricultural purposes. Most of the agricultural lands have become barren and infertile.

In the uncontaminated areas the concentration of these ions are comparatively very low, whereas in the contaminated areas, very high levels are found rendering the water unfit for all uses. The concentration of sodium ranges from 4 to 2960 mg/l whereas potassium ranges from 1 to 360 mg/l. These high values indicate the contribution of these salts from the seepage of effluents.

In the study area, ground water is usually alkaline in nature. Bicarbonate is the dominant anion contributing to alkalinity. The alkalinity is low in the unpolluted areas, whereas it is high in the contaminated areas. The bicarbonate ion concentration ranges from 140 to 1165 mg/l. In most of the wells bicarbonate is in excess of the BIS limit for drinking water quality standard.

Chloride is major anion in the ground water of the study area. In the unpolluted areas, chloride is found to be less than Bicarbonate where as Chloride is the dominant an ion in ground water in the contaminated areas. Sodium chloride is the major compound used in the dyeing and bleaching processes and it is the major source of contribution of Chloride to ground water. In the area, out of the 86 samples collected chloride concentration ranges from 18 to 6773 mg/l. In majority of the area chloride concentration is beyond the permissible limit for drinking water. In the contaminated areas salinity is found to be high rendering the water unfit for domestic, livestock and agricultural purposes.

Sulphate is another prominent anion, next only to Chloride in the ground water in the area. It is present in amounts higher than the permissible limits at various locations. Like other constituents, the concentration of sulphate is more in the contaminated wells and in the dyeing and bleaching process sulphates are being used at various stages. Out of the 86 wells sampled sulphate concentration ranges from 8 mg/l at Mangalam to a maximum of 2000 mg/l at Manur. In many areas, sulphate concentration exceeded the prescribed limit for drinking as per BIS.

Nitrate is a critical constituent, which indicates the extent of anthropogenic pollution. Nitrate is found to be quite high in the ground water of the study area. Out of the 86 water samples collected from various wells 18 wells have nitrate concentration below 45 mg/l the limit for drinking water as per BIS. In the remaining wells Nitrate concentration is more than 45 mg/l with the maximum value of 714 mg/l at Authupalayam. In the unpolluted, areas Nitrate is found to be less than Chloride and bicarbonate, whereas in the polluted areas Nitrate is the one of the dominant anions, which confirms their anthropogenic origin.

Fluoride concentration in the study area ranges from 0.2 to 7.00 mg/l. Out of the 86 wells sampled fluoride concentration exceeded 1.5 mg/l in 18 wells with the maximum of 7.00 mg/l at Vayakattupudur. Some of the severely polluted areas have fluoride concentration more than 1.5 mg/l at Mannur, Vayakattupudur, Pudur, Mallainaickanur and Siruvelampalayam. All the locations mentioned above have fluoride more than 2.0 mg/l.

To assess the organic contamination of ground water , BOD and COD were determined. In some of the wells, ground water was found to be coloured. The colour ranges from yellow to red and blackish. The effluent discharged from the industries carries unfixed dyes, pigments and other colouring matter. Though biological degradation reduces these matters considerably and because of their low solubility in water, organic matter in ground water is comparatively less, than surface water. The bio-chemical oxygen demand (BOD) value ranges from < 1 to 17 mg/l and chemical oxygen demand (COD) ranges from 8 to 104 mg/l. In addition to the industrial pollution, urban waste water and solid waste also contributes considerable organic matter to ground water. Observation wells at weekly market, TMC Colony, Perichipalayam and Kovil vazhi – I which are located within the town, thickly populated areas shows COD values ranging from 16 mg/l to 96 mg/l, whereas BOD of these wells are 3,2,4 and 1 mg/l respectively, which indicates the biochemically degradable organic matter is less. Well No.80 which is located at the Tiruppur weekly market is showing COD value of 96 mg/l which shows the effects of garbage and other solid waste storage inside the market, contributes the organic matter to the ground water. Similarly, in the contaminated areas, most of the well samples have high COD values, which indicates the contribution of organic matter due to the industrial pollution. The industrial contribution of organic matter is further confirmed by the BOD and COD values of surface water samples from the dam and the Nallar river sample that have BOD values of 29 and 79 and COD values of 56 and 128 respectively. The river carries both the treated and untreated effluents from the industrial units situated along the river course. The river and dam water were found to be dark coloured with unpleasant odour. Some of samples collected from the monitoring wells also have unpleasant odour.

To assess the presence of trace metals, 31 water samples were collected from the monitoring wells tapping the phreatic aquifers. Concentration of metals like Chromium, Lead, Cadmium, Iron, Zinc and Manganese were determined using Atomic Absorption Spectrophotometer. Most of the samples were collected from the contaminated areas. Metals like Cadmium and Lead are below detectable limit in all the samples, whereas Iron, Manganese and Zinc are found in measurable levels. Iron is present in two wells located at Mangalam and Agraharam showing concentrations greater than 1.00 mg/l, and in 9 wells iron is more than 0.3 mg/l, above which iron may impart unpleasant taste to drinking water. Manganese is also found in all the water samples analyzed. Out of the 31 samples analyzed 14 samples have Manganese more than 0.1 mg/l, the prescribed limit for drinking. Zinc is also found in measurable qualities in most of the samples but well below the desirable limit for drinking water.

Among the heavy metals analysed, Chromium is present in excess of the permissible limit of 0.05 mg/l in 6 wells. These 6 wells are located in the severely affected areas and the maximum Chromium value of 0.1 mg/l was noticed at Mannur, which has the maximum EC value of 19390 µm/cm at 25°C.

A comparison of analytical data of samples collected during 1975 and 2000 was made. Observation well data of 1975 for wells located at Mangalam, Kuppadampalayam, Nachpalayam and Thirumauruganpoondi are compared with the same well data for 2000. Chinnakarai and Ammapalayam observation wells are compared to the nearest available wells viz. Tiruppur weekly market and Velampalayam respectively. It is found that an overall increase is observed in EC, TH, Ca, Mg, Na, Cl, NO_3 and F. The concentration of Na^+ makes ground water unfit for irrigation as it will increase the exchangeable Na+ content of the soil. This affects the soil permeability and texture and leads to piddling and reduces the rate of water intake by plants. A significant increase of NO_3 is noticeable in the bank of river Nallar (Thirumuruganpoondi and Velampalayam).

A perusal of results of chemical analysis of exploratory wells drilled in 1980 under SIDA project reveal a marked decrease in overall constituents with increase in depth. Ground water in Moyandampalayam well with a depth of 187 m bgl is less mineralized when compared to Kungumapalayam exploratory well having depth of 121 m bgl.

The ground water all along the Noyil river is highly polluted and unfit for any purpose. The agriculture lands, which were irrigated with this polluted ground water have become infertile and barren.

6.6 GROUND WATER POLLUTION IN AMBATTUR INDUSTRIAL AREA

Central ground Water Board, South eastern coastal region during its Annual Action plan 2002-2003, took a pollution study in and around Ambattur Industrial Estate. The Plate-6.6.1 shows the Ambattur Industrial Estate Layout.

6.6.1 BACKGROUND INFORMATION

The study area is a sub-Urban area of Chennai Metropolitian city and located NW of the city. It has an extent of 42.5 Sq km and is located between Lat. 13° 03' 01'' S to 13° 20' 58'' N and Longitude from 80° 06' 00'' to 80° 39' 58'' It is bounded by Couum river in west and south.

The soil classification based on the soil survey and land use organization, that shows the Ambattur area is covered by Inceptisoils. These are red sandy and Brown Clayey soils. It is grey to pale brown in colour, the thickness of soil ranges between 25 and 45 cms. This soil is well drained and shows good permeability. It is transported in origin.

The industrial Estate and its environs is underlain by recent alluvium followed by tertiary sandstone. The average water level during pre monsoon and post monsoon periods range from 5.36 mbgl to 3.20 mbgl. The average fluctuation is 2.17m.

Industrial activity has flourished in and around Ambattur Industrial Estate for several years now. The Predominant industries are Engineering industries, which involves cutting, milling, shaping and sizing. An offshoot of Engineering industry is the electroplating industry, which specializes in metal coatings of different micron size. This industry uses acids for washing and pH stabilization.

Also prevalent in the area are chemical industries mainly engaged in paint and standard chemicals. Food and Bevarage industry is located in the Ambattur industrial Estate. Gas and Rubber industries are also located in this area catering to other industries of all manufacturers. A list of major industries located with in the Ambattur Industrial Estate is given in the Table-6.6.1.

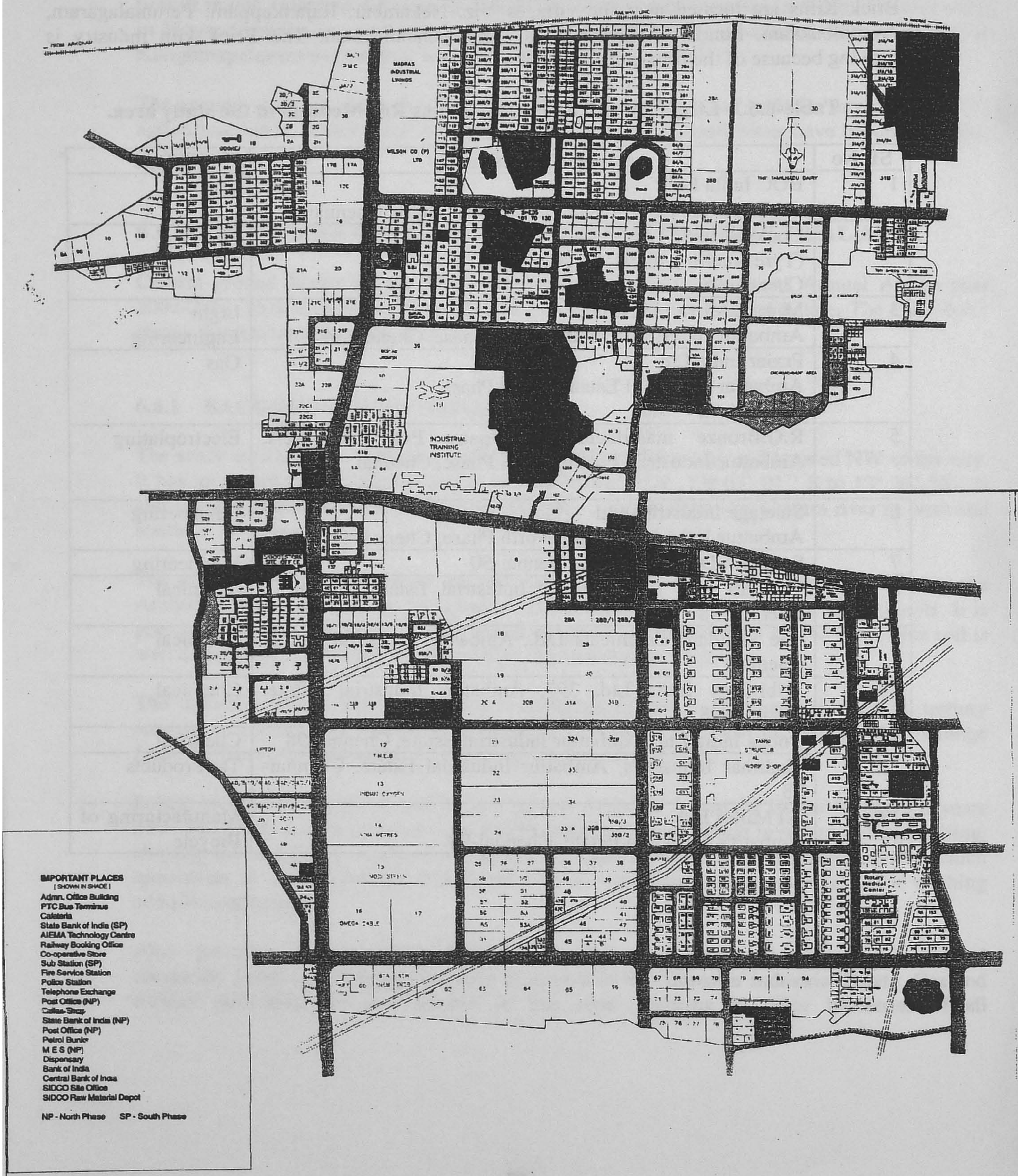
Open cast mining of clay is carried out north of river Cooum mainly for making bricks. The Brick Kilns are located near the villages Viz. Nekambur, Rajankuppam, Perumalagaram, Ayanmbakkam, Sundaracholapuram and Ayyaanambakkam. The Brick kiln industry is thriving because of the proximity to the city.

Table-6.6.1 List of Industries categorized as Red Medium in the study area.

SI. No	Name of the Industry	Type
1	BOC India Ltd, Ambattur Industrial Estate, 21E, North Phase, Chennai	Gas
2	Cookson India Ltd, (Tyre smelting division), Ambattur, Chennai.98	Foundry
3	Mirra &Mirra Industries, Ambattur Industrial Estrate, North Phase, Chennai-98	Light Engineering
4	Prxiar India Ltd Ambattur Industrial Estate, North Phase, Chennai-98	Gas
5	R.G.Bronze manufactures company Pvt. Ltd. 32A, Ambattur Industrial Estate, North Phase, Chennai	Electroplating
6	Steelage Industries Ltd Ambattur Industrial Estate, North Phase, Chennai-98	Engineering
7	Sundram Dynacast Padi, Chennai-50	Engineering
8	Tetradra Ltd, 17A, SIDCO Industrial Estate, Ambattur, Chennai-98	Chemical
9	The Standard Chemicals Ltd., Ambattur Industrial Estate, Chennai	Chemical
10	Tribiology India Ltd, 397, Ambattur Industrial Estate, Chennai-98	Chemical
11	Cooks India Ltd., Ambattur Industrial Estate, Chennai-98	Chemical
12	Shalimar Industries, Ambattur Industrial Estate, Chennai-98	Tar Products
13	T.I Miller Ltd Ambattur Industrial Estate, Chennai-98	Manufacturing of Bicycle

AMBATTUR INDUSTRIAL ESTATE

LAYOUT PLAN



SOURCE: TAMIL NADU POLLUTION CONTROL BOARD

Table –6.6.2 List of Industries Categorized as Red Large in the study area

SI. No	Name and Address	Type
1	Brakes India Ltd., Padi, Chennai	Engineering
2	Brittania Industries Ltd., MTH road, Padi, Chennai-50	Food and Bevarages
3	Fidelity Industries Ltd., Padi, Chennai-50	Chemical
4	Lucas-TVS Ltd., MTH Road, Padi	Engineering
5	MIL Industries Ltd., 25A, SIDCO Industries Estate	Rubber
6	Sundaram Brakes	Engineering
7	Sundaram Clayton Ltd., Padi, Chennai-50	Engineering
8	Sundaram Fasteners Ltd., Padi, Chennai-50	Engineering
9	Wheels India Ltd., Padi, Chennai-50	Engineering

(Source: Tami Nadu Pollution Control Board.)

6.6.2 RESULTS OF THE STUDY

The ground water quality of the study area is seriously impaired due to the industrialization in the area. The Electrical conductivity (EC) of the ground water ranged from 545 - 5410 Ms/cm at 25°Cduring pre monsoon (Plate-6.6.2) to 650-5430 μS/cm at 25°C during post monsoon period. All the major ionic constituents behaved in a similar manner. The rainfall recharge had minimal effect on ground water quality during the study period.

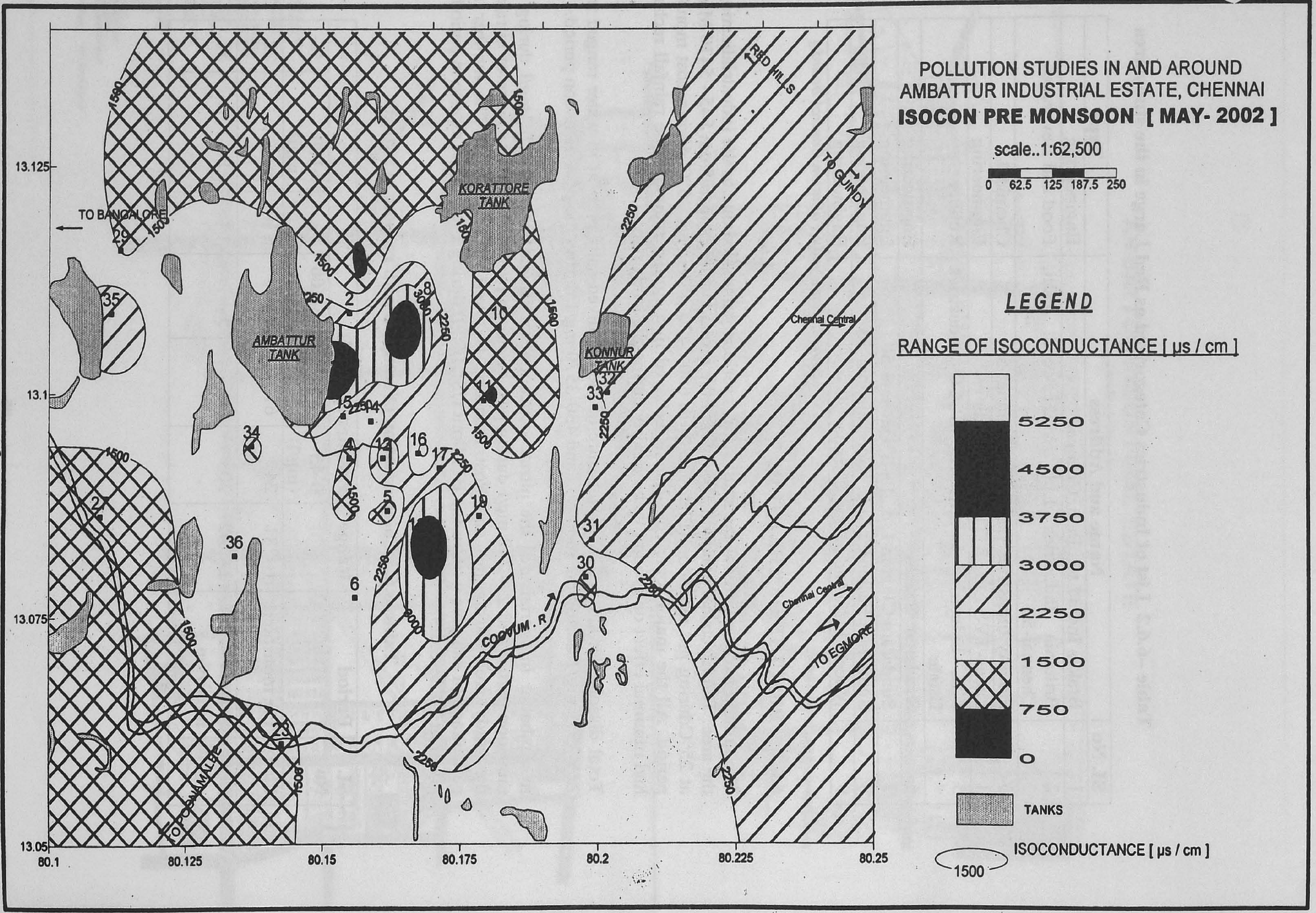
Total dissolved solids (TDS), a measure of the dissolved salts present in water ranged from 275-3579 mg/1 during pre monsoon and 430-3570 mg/1 during the post monsoon period.

In Ambattur industrial area the nitrate concentration ranged from 1 – 281mg/l during pre monsoon period and 2 – 242 mg/l during post monsoon period. The comparison of nitrate in the study area during pre and Post monsoon is given Plate – 6.6.3. The number and percentage of samples with in the BIS limit (IS:10500) during Pre & Post monsoon periods is given in Table-6.6.3.

Table-6.6.3 Categorisation of samples with respect to Nitrate

SI. No	Period	Range	Frequency (mg/l)					
			0-45 (mg/l)	%	46-100 (mg/l)	%	>100 (mgl)	%
1	Pre monsoon	1- 281	24	67	4	11	8	22
2	Post monsoon	2 –242	20	56	5	14	11	31

PLATE -6.6.2



POLLUTION STUDIES IN AND AROUND
AMBATTUR INDUSTRIAL ESTATE, CHENNAI
ISOCON PRE MONSOON [MAY- 2002]

The analytical data indicates that the area has been contaminated severely with respect to Nitrate. It is observed that industrial pollution as well as domestic wastes contributes to nitrate content, as higher values are noticed in domestic wells as well as wells located near the garbage dumping sites. e.g well nos. 3, 8, 15, 9, 27 located in the banks of water bodies are showing elevated levels of nitrate. Similarly about 42% of the samples shows nitrate < 10 mg/l during pre monsoon period, most of which are located inside the industrial estate area. This reveals the fact that not all the industries contribute to nitrate pollution. Hence, the type of waste generated is important in causing the nitrate pollution. In the majority of cases, residential and industrial areas cannot be distinguished, hence the source of nitrate could not be ascertained. During post monsoon period, the concentration of nitrate increased appreciably, which probably could be due to leaching from the nearby dumped wastes. Table-6.6.4 shows the wells, which were showing substantial increase of nitrate during post monsoon period.

From the above observation it may be concluded that moderately to very high concentration of nitrate above permissible limit noticed in different aquifers due to rapid industrialization, dumping of domestic waste materials etc. Comparatively higher values of nitrate found in phreatic aquifer, which required proper drainage &sanitation system in ground water regime.

Table-6.6.4 Seasonal Variation of Nitrate Concentration

Sl. No	Well No	Location	Nitrate(mg/l)		% of increase
			Pre monsoon	Post monsoon	
1	1	Ambattur Railway Station	24	54	125
2	7	Ambattur – SBOA School	72	102	42
3	9	Patravakkam – Drilcos Ind.	14	30	114
4	13	Ambattur Ind Estate – Vinayagar temple	137	170	24
5	17	Tiny sector	13	158	1115
6	33	Padi – Tiruvaleswarar temple	123	202	64

The Chloride ion concentration ranged from 78 to 1312 mg/1 during pre monsoon period and from 64 to 1298 mg/1 during post monsoon period.

The concentration of Fluoride is within the permissible limit of 1.50 mg/l during pre monsoon period except in one well at Avadi whereas during post monsoon period, fluoride content of all the wells are with in the permissible limit of BIS(IS10500:1991)

Heavy metal like Copper, Zinc, Chromium, Cadmium, Lead, Iron and Manganese in ground water samples were analysed. Range of heavy metals in ground water is given in Table-6.6.5. Among these Copper & Zinc were well below the permissible limits prescribed by BIS.

Table 6.6.5 Range of heavy metals observed in the ground water of the study Area

No	Metal	Pre monsoon	Post monsoon
1	Copper	BDL – 0.025	NA
2	Cadmium	BDL – 0.204	BDL – 0.014
3	Chromium	BDL – 0.112	**BDL – 0.061
4	Lead	0.007-4.585	BDL – 1.056
5	Iron	BDL – 9.215	BDL – 2.563
6	Manganese	BDL – 1.770	BDL – 1.965
7	Zinc	BDL – 3.310	*NA

*NA-Not Analysed, **BDL : Below Detection limit (0.001mg/l)

The concentration range (mg/l) of toxic heavy metals during pre monsoon are as follows Cadmium: BDL – 0.20, Chromium: BDL – 0.112, Lead: 0.007-4.585, iron: BDL – 9.215, Manganese: BDL – 1.770

The concentration range (mg/l) of heavy metals during the pre monsoon period is as follows Cadmium: BDL – 0.014, Chromium: BDL – 0.061, Lead: 1.056, iron: BDL – 2.563, Manganese: BDL – 1.965.

It is found that the ground water of the area is heavily polluted especially with toxic heavy metals besides having high TDS and other inorganic major constituents.

During the pre monsoon season the Copper concentration in ground water ranged from 0.001 mg/l to 0.011 mg/l. Copper was noticed only in five samples out of all 36 samples. In most of the samples, Copper was found to be BDL.

The comparison of Cadmium in the study area between pre & post monsoon is shown in **Plate-6.6.4**. In the pre monsoon period, out of 36 samples analysed Cadmium was detected in three samples and all the three samples showed levels of Cadmium in excess of permissible limits. The highest value was noticed at a dug well at Athipattu (0.204 mg/l)

During the post monsoon period, Cadmium concentration ranged from 0.001 mg/l to 0.034 mg/l. It was observed that during post monsoon season, the concentration of Cadmium is reduced considerably. The well at Athipattu showing the highest value of 0.204 mg/l during pre monsoon period has shown 0.002 mg/l during postmonson period. Similarly in all the three samples, Cadmium concentration was considerably reduced. However, during post monsoon period more number of samples were found to contain Cadmium. This might be due to the decrease in pH noticed in most of the samples during post monsoon period.

The distribution of Chromium during the pre and post monsoons periods is shown as bar diagram in Plate-6.6.5. During the pre monsoon period Chromium concentration ranged from BDL – 0.191mg/l, whereas it ranged from BDL to 0.061 mg/l during post monsoon period. It is observed that the wells containing high levels of Chromium (>0.05mg/l) are located near

PLATE-6.6.3

Comparsion of Nitrate between premonsoon and postmonsoon periods (May,2002-February,2003)

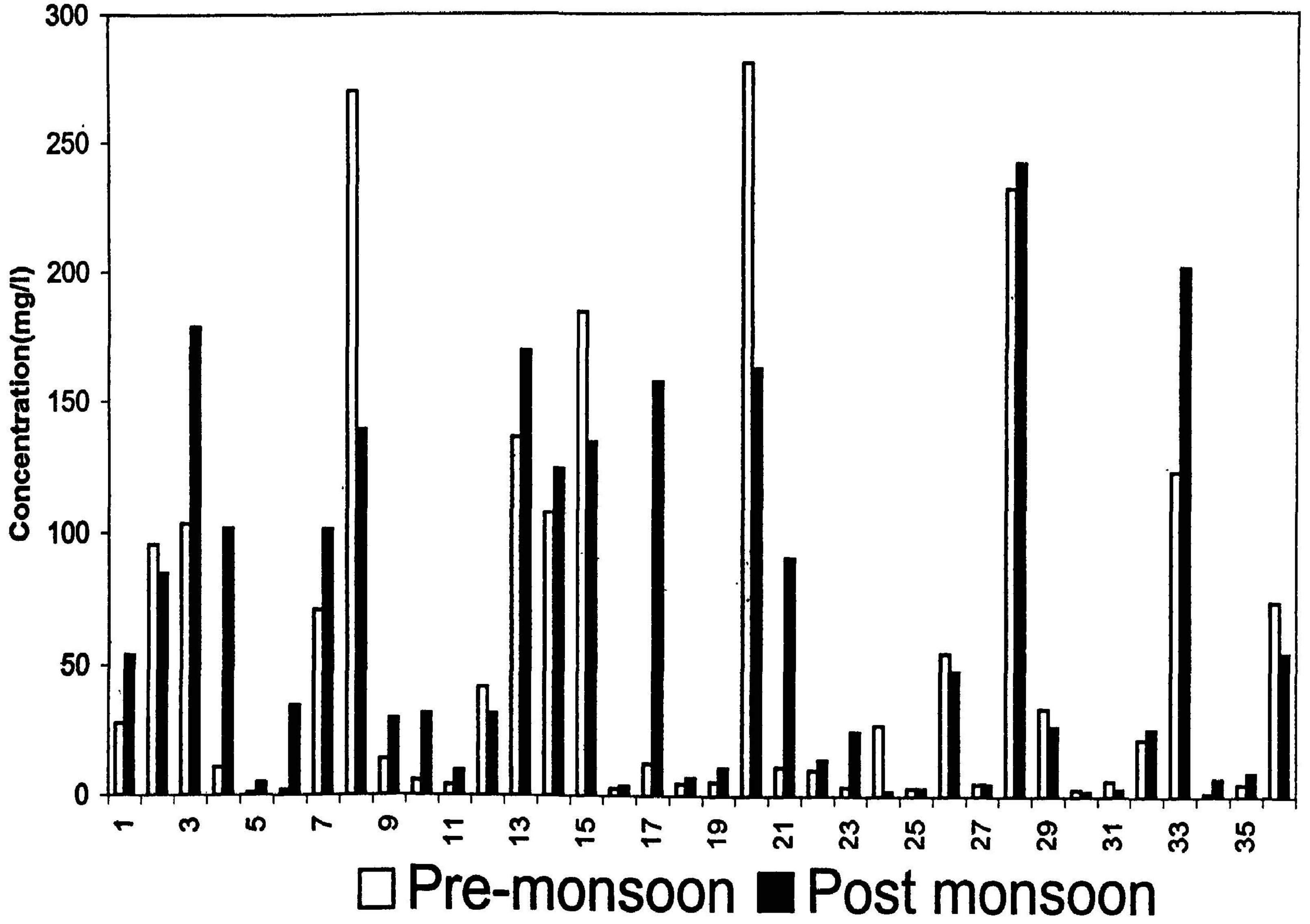
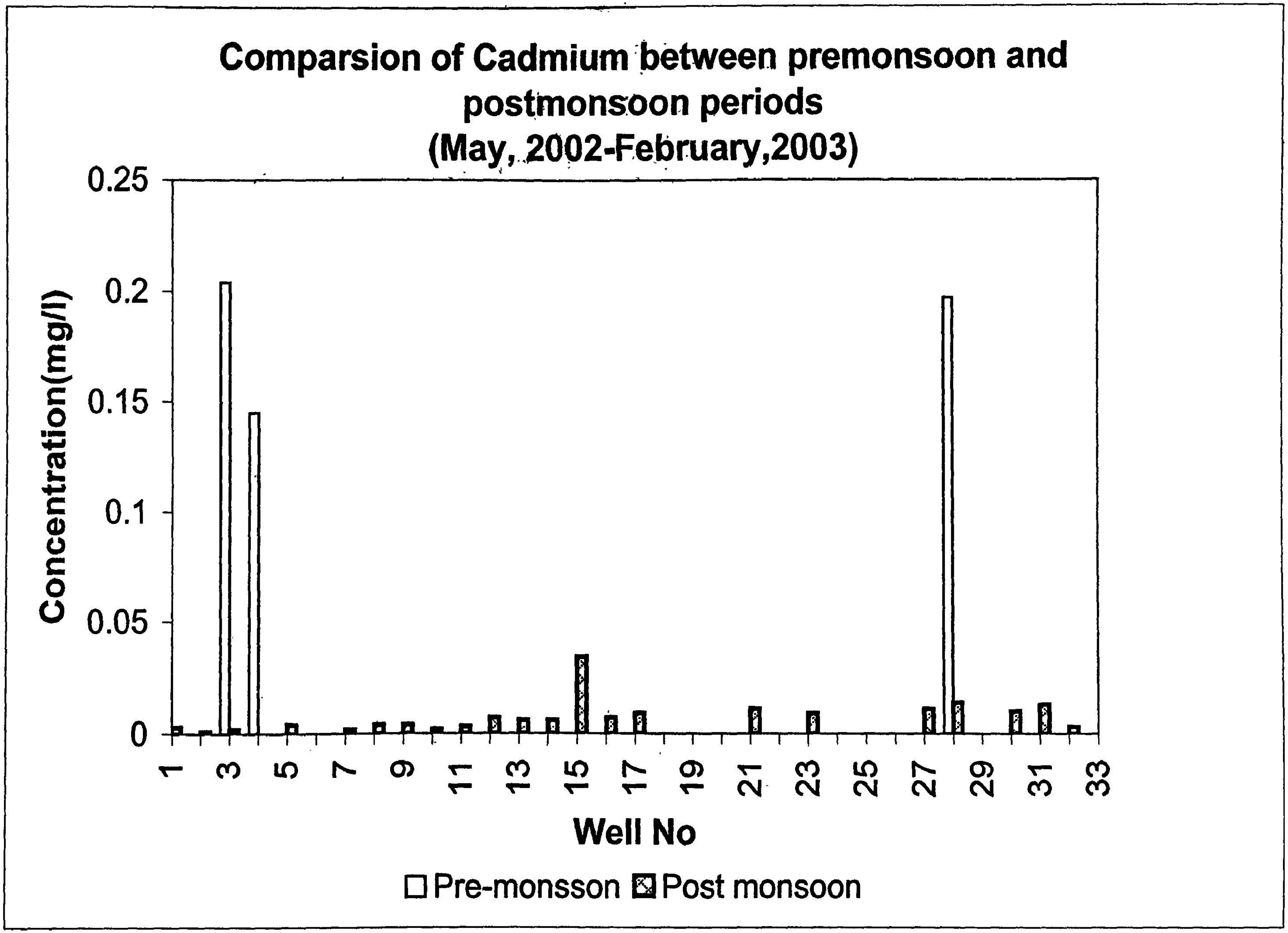
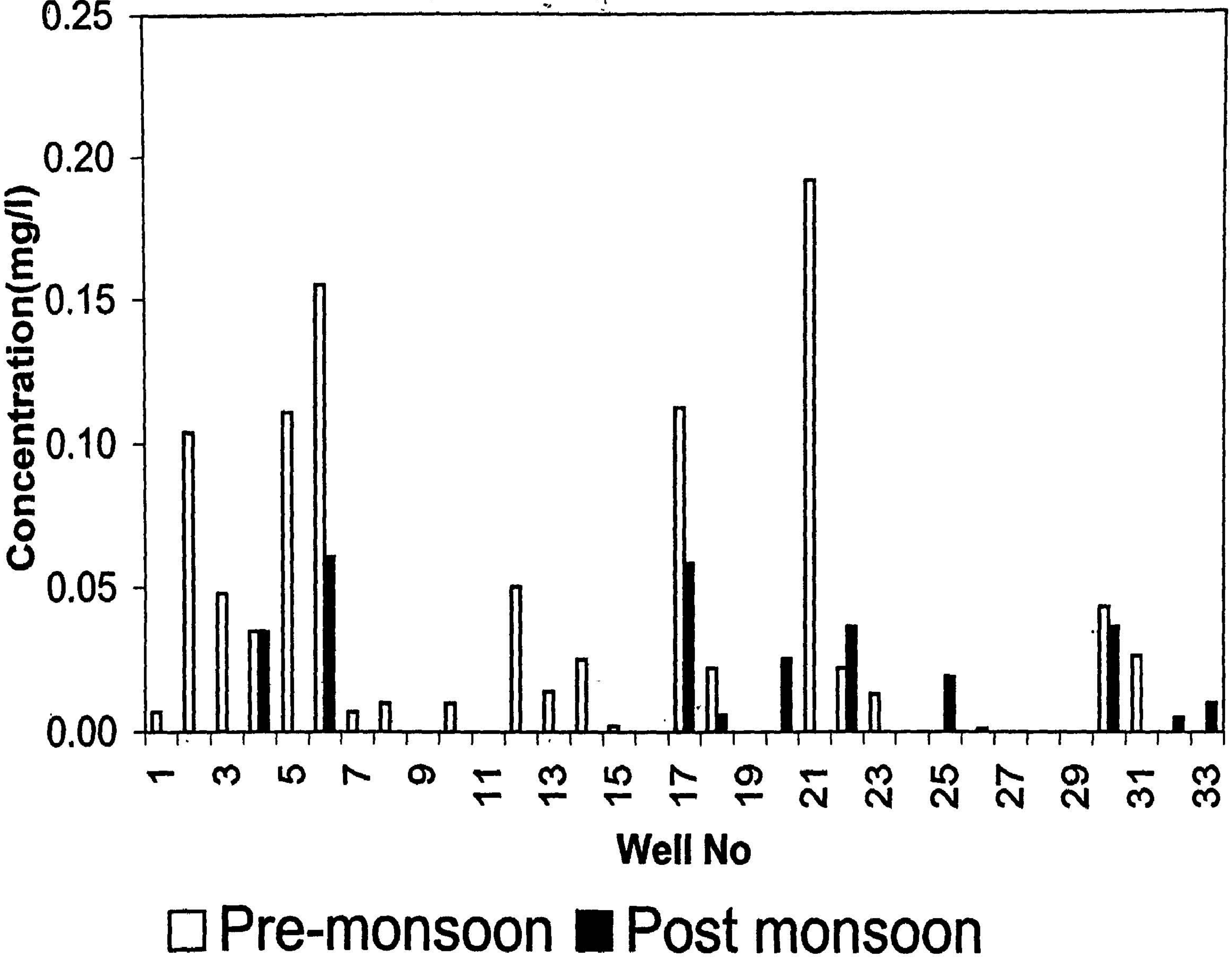


PLATE- 6.6.4



Comparsion of Cadmium between premonsoon and postmonsoon periods
(May, 2002-February,2003)

DISTRIBUTION of Chromium DURING premonsson and postmonsoon periods
(May, 2002-February,2003)



electro plating industries. Wells located at Padi (well no 20) Patravakkam (No.8) are located adjacent to such industrial units. Many of these industries are recorded to dispose their wastes through small injection wells, which directly infiltrate in to the aquifer and contaminate the ground water. Out of the 36 samples analysed chromium was detected in 19 samples, which account for about 53%. Among these in 6 samples it exceeded the BIS limit (0.05mg/l).

The pre monsoon Lead concentration in ground water ranged from 0.007 to 4.585mg/l. During pre monsoon period, Lead was found to be present in all the 36 samples analyzed and maximum value of lead was noticed at Attipattu (4.585mg/l). Similar high values were noticed in the wells at Kilayanambakkam (3.785mg/l) and Asiatic colony (4.290 mg/l). During the post monsoon period it is found to have reduced substantially. The highest values noticed during pre monsoon period, ie., Athipattu (4.585 mg/l) is reduced to 0.505 mg/l. Similarly the other two wells Kilayanambakkam) and Asiatic colony shows 1.056 mg/l and BDL respectively, during post monsoon period. A comparison of Lead concentration during pre and post monsoon periods is shown in bar diagram in **Plate-6.6.6.**

The presence of appreciable quantity of lead in ground water of the study area indicates that the industrialization has resulted in severe contamination of ground water. This is evidenced by the presence of lead in all the wells during pre monsoon period. Out of 36 wells, 23 were found to contain lead in amounts exceeding permissible limits prescribed by BIS, which account for about 64% of the analyzed samples. Most of the wells located inside the industrial area were found severely polluted. During post monsoon period 5 samples exceeded the BIS limit, which accounts for about 14% of the total samples.

No. of samples falling different categories of iron concentration is given in Table-6.6.6.

Table-6.6.6 Categorisation of samples with respect to Iron

S. No	Classification	With in limit				Above the limit			
		Pre		Post		Pre		Post	
		No	%	No	%	No	%	No	%
1	Desirable (0.3 mg/l)	14	40	23	66	21	60	12	34
2	Permissible (1.00 mg/l)	10	29	5	14	11	31	7	20

In the study area out of 36 samples collected, high values of manganese were noticed in several wells, similar to iron. During the pre monsoon season manganese concentration ranged BDL to 3.085 mg/l. The post monsoon concentration ranged from BDL –1.965mg/l. Table-6.6.7 gives the number and percentage of samples within and above the limits of desirable and permissible limit for drinking water in the absence of alternate sources.

PLATE-6.6.6

CONCENTRATION of Lead DURING premonsoon and postmonsoon period (May,2002-February,2003)

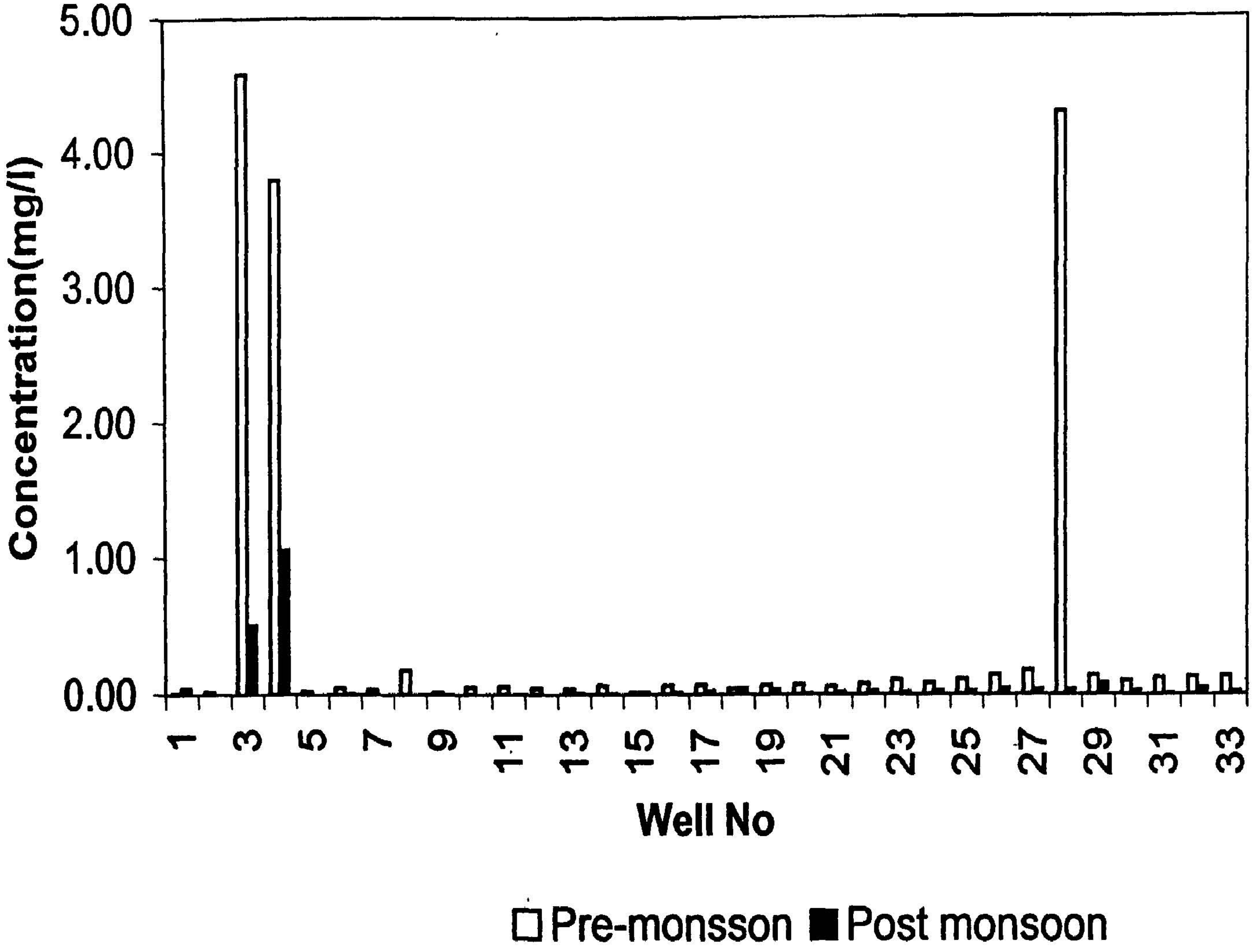


Table-6.6.7 –Categorisation of samples with respect to Manganese

S. No	Classification	With in limit				Above the limit			
		Pre monsoon		Post monsoon		Pre monson		Post monsoon	
		No	%	No	%	No	%	No	%
1	Desirable (0.1 mg/l)	10	28	18	50	26	72	18	50
2	Permissible (0.3 mg/l)	7	19	5	14	19	53	13	36

It is observed that during the post monsoon period, there is a substantial decrease in the Manganese concentration. This could be due to the dilution effect as well as the oxidation of Mn^{2+} from in to the insoluble Mn^{4+} form, which are deposited as $Mn0_2$. A comparison of Manganese during pre monsoon and post monsoon is shown in **Plate-6.6.7**

During the pre monsoon period, the concentration of Zinc ranged from BDL-3.310 mg/l. All the wells contain appreciable amount of it, suggesting the possibility of its origin from industrial waste disposal. No sample is found to contain Zinc above the desirable limit (5mg/l). High values though within desirable limit are noticed at wells located near electro plating and fabricating industries.

6.7 GROUND WATER POLLUTION IN CHROMPET AREA, KANCHEEPURAM DISTRICT

Chrompet an industrial area in the suburbs of Chennai, has a large number of tanneries. Ground water pollution study was carried out in this area during 2004-06.

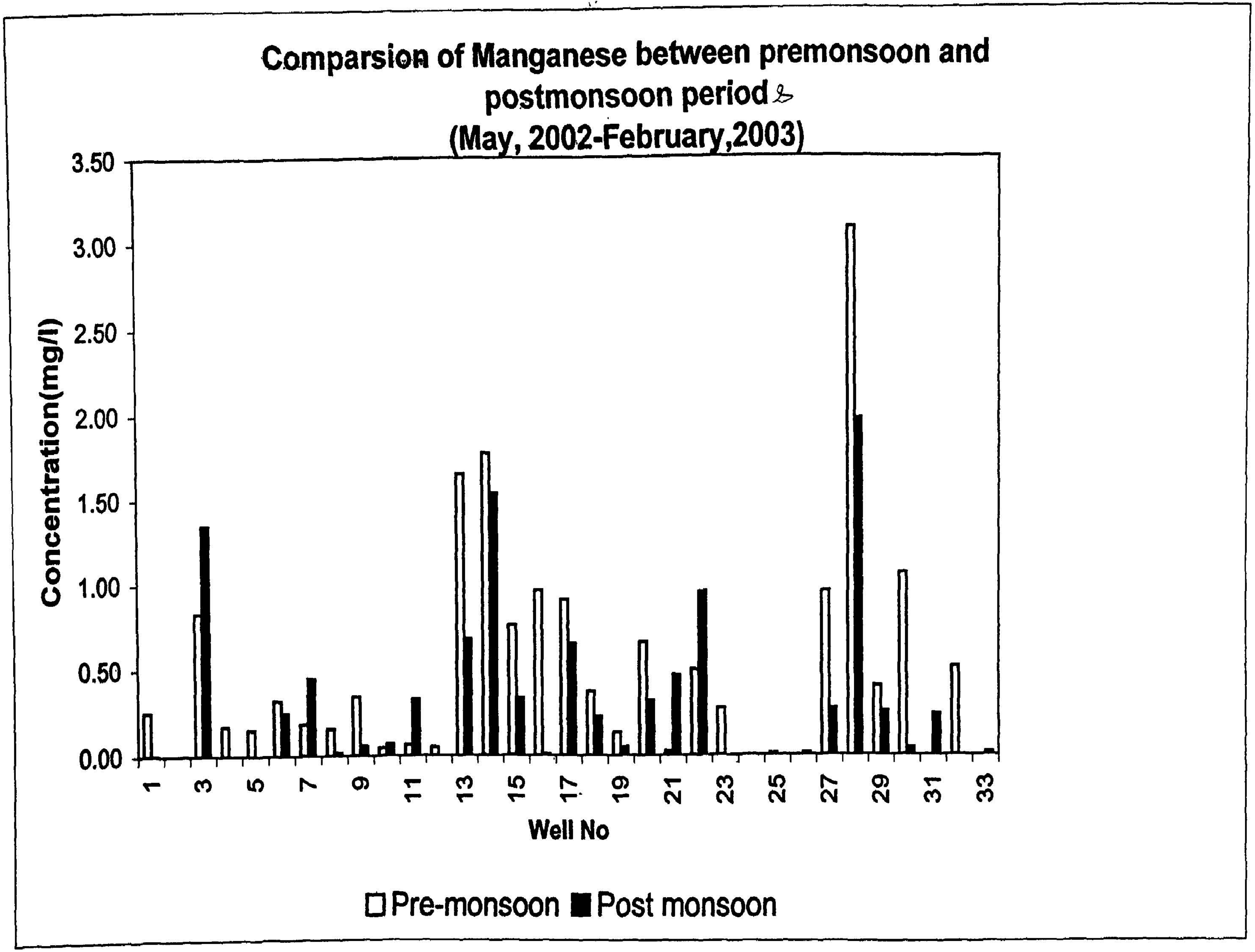
6.7.1 BACK GROUND INFORMATION

The study area has an aerial extent of 45 Sq.km is covered by N.latitude 12° 56' 12" to 12° 59' 56" and E longitude from 80° 06' 14" to 80° 11' 30", covered by Survey of India toposheet No. 66 D/1. The area is located on the National Highways No.47 and about 3 Km south of Chennai airport. It is bounded by Adyar river in west and Chrompet-Thoraipakam road on east. The area is accessible by Southern Railway line connecting Chenai Egmore with Tambaram. The railway line as well as the NH-47 bisects the study area.

Chrompet industrial area, a sub urban of Chennai Metro is located in southwestern part of the city. It falls in Tambaram Taluk of Kancheepuram District, Tamil Nadu. The area covers several suburban settlements that include Pallavaram, Pammal, Anakaputhoor, Thiruneermalai, Cowl Bazar, Pollichalur, Old Pallavaram and Kilkattalai.

Major area is residential and followed by industrial/commercial zone. Industries are concentrated mainly on the western part of NH-47. The eastern portion of NH-47 is predominantly residential area with only a few industries located in the area. Though it was

PLATE 6.6.7



Comparsion of Manganese between premonsoon and postmonsoon period
(May, 2002-February,2003)

away from residential areas when the tanneries came up nearly a century ago, not it has become part of Chennai city with a substantial population residing there. Most of the tanneries are located on either side of the road from Chrompet to Thiruneermalai. A few tanneries are also located on the eastern side of the study area (old Pallavaram), but they are not functioning now.

Industrial activity, mainly tanneries have flourished in the area, which are century old. The area houses 152 tanneries. Four tanneries process raw hidges into wet blue and 126 tanneries process wet blue to finished leather. About 3000 m^3/day of effluents are generated and are treated at the common effluent treatment plant (CETP) located in the area. The CETP started its operations from February 1995, and it is operated and maintained by the Pallavaram Tanners Industrial Effluent Treatment Company Ltd.(PTIET). Among the other industries the TEXTAN, which manufactures chemicals for textile and tanneries is located at old Pallavaram. The tanneries are classified as "Red Category" industry by pollution control authorities, which indicate its severe polluting nature. (*Source: The Pallavaram Tanners Industrial Effluent Treatment Company Ltd (PTIET)*)

The nearest observatory is located in Nungambakkam (IMD). The normal annual rainfall is 1247.6 mm (1905-2005). August to December is the main rainy season when about 80% of the annual rainfall is received. October and November being the rainiest months. In the 63 year period the highest annual rainfall amounting to 205% of the normal occurred in 2005. The Heaviest monthly rainfall recorded was 1077 mm during October 2005. The lowest annual rainfall, which was only 68% of the rainfall, occurred in 1973. (*Source: OIMD and State Economics and Statistics Dept.*)

The area is underlain by charnockites of archaean age. In the study area 65 dug wells were established for monitoring. The depth of sampled wells ranged from 3.32 to 14.15 m bgl. The depth to water level ranges from 0.70 to 13,77 m bgl during pre monsoon (June-04) and 0.38 to 8.56 m bgl during post monsoon season (Jan-05). The range of various chemical constituents observed is given in the following Table-6.7.1

Table-6.7.1 :Range of Chemical Constituents observed in Ground Water

S. No.	Parameter	Pre-monsoon		Post monsoon	
		June-04	June-05	Jan-05	Jan-06
1	2	3	4	5	6
1	pH	6.96-8.18	6.95-7.95	6.50-8.20	6.66-7.57
2	EC(µs/cm at 25°C)	605-11660	745-10540	600-10260	250-10735
3	Total Dissolved Solids (TDS) (mg/l)	400-8170	410-8432	405-7695	158-8051
4	Total Hardness as $CaCO_3$ "	135-3580	210-3030	176-2490	60-2490
5	Calcium "	18-776	28-688	16-563	20-563
6	Magnesium "	21-399	10-318	13-263	0-263
7	Sodium "	41-2600	30-2100	31-2050	30-2150
8	Potassium "	0-170	0-70	0-150	0-170
9	Carbonate "	-	-	-	-

1	2		3	4	5	6
10	Bicarbonate	"	73-650	73-1061	27-902	65-707
11	Chloride	"	70-3205	60-2836	57-2921	40-2970
12	Sulphate	"	46-1606	34-1486	28-1090	10-1160
13	Nitrate	"	2-452	1-769	0-381	0-644
14	Nitrate-N	"	0.00-11.75	0.02-0.50	0.00-8.52	0.00-0.56
15	Fluoride	"	0.24-1.48	.33-1.72	0.13-1.25	0.01-1.28
16	Phosphate-P	"	0.24-1.48	0.06-0.99	0.00-0.41	0.02-1.19

Electrical Conductivity of water is due to all the dissolved ionic matter and it is a good indicator of pollution, as most dissolvable pollutants exist as ions in water. In the study area the pre-monsoon EC values ranged from 605 to 11660 μs/cm at 25°C.

The pre-monsoon and post monsoon data indicate that the ground water of the study area is highly mineralized as compared to the unpolluted wells of the same area. The wells located in relatively unpolluted area have EC values from 605 to 1500 μs/cm at 25°C. Hence these could be taken as the background values of the area and other wells may be compared to these, in order to assess the pollution caused by industrialization. Most of the wells in the study area show higher values of EC showing the extent of industrial pollution. This is more pronounced in the Nagalkeni area where most tanneries are clustered. Similarly wells located near by tanneries on the eastern side of the study area show EC values > 4000 μs/cm at 25°C. A comparison of the average values (65 wells) of EC for the pre and post monsoon periods of 2004-05 and 2005-06 reveals that the EC values are reduced by 15 and 25% after monsoon. The 25% reduction observed during January 2006 is due to the excessive rainfall received during northeast monsoon season.

High concentration of Sodium, Chloride, Sulphate and Nitrate beyond the permissible limit of drinking water has been observed in the wells having high EC.

The range of heavy metals in ground water in different season is given in Table-6.7.2.

Table-6.7.2 : Range of Heavy metals in ground water of the study area

S.No.	Metal	Pre-monsoon		Post monsoon	
		June-04	**June-05**	**Jan-05**	**Jan-06**
1	Copper	BDL-0.29	BDL-0.58	BDL-0.02	BDL-0.01
2	Cadmium	BDL-0.04	BDL-0.08	BDL-0.01	BDL-0.01
3	Chromium	BDL-0.291	BDL-0.178	BDL-0.25	BDL-0.065
4	Lead	BDL-0.22	BDL-0.18	BDL-0.07	BDL-0.05
5	Iron	BDL-1.92	BDL-2.56	BDL-1.92	BDL-1.75
6	Manganese	BDL-2.05	BDL-3.05	BDL-0.85	BDL-1.00
7	Zinc	BDL0.69	BDL-1.02	BDL-2.50	BDL-3.0

During the pre monsoon periods Chromium concentration ranges from BDL-0.291 (June-04) and BDL to 0.178 mg/l (June-05), whereas it ranged from BDL to 0.250 and BDL to 0.065 mg/l during post monsoon period. BIS has recommended 0.05 mg/l is the maximum permissible limit for Chromium in drinking water. During the pre-monsoon periods of June-04 and June-05, 15 and 12 samples have Chromium more than the permissible limit of 0.05 mg/l, and, the corresponding post-monsoon periods (Jan-05 and 06) 9 and 4 samples have more than the permissible limits. It is observed that almost all wells containing high levels of chromium (>0.05 mg/l) are located near by tanning industries.

High concentration levels of Iron were observed in some of the wells. During the pre monsoon periods (June-04 and June-05) 2 and 3 samples contained more than the permissible limit of 1.0 mg/l. During post-monsoon periods (Jan-05 and Jan-06) 3 and 2 samples contained Iron more than the permissible limit. The presence of iron is noticed mainly in the wells located nearby waste disposal sites and wells located near by sewage lines. Hence, it may be concluded that the changes in redox condition might have caused the mobilization of Iron.

In the study area high values of Manganese were noticed in several wells, similar to Iron. Out of 65 samples collected during pre-monsoon periods (June-04 and June-05) 13 and 14 samples contained more than the BIS limit of 0.3 mg/l. During the post monsoon periods (Jan-05 and Jan-06) 8 and 5 samples contained more than the BIS limit. It is observed that during the post monsoon period, there is a substantial decrease in the Manganese concentration. This could be due to the dilution effect as well as the oxidation of MN^{2+} from in to the insoluble MN^{4+} form, which are deposited as MNO_2.

6.7.2 RESULTS OF THE STUDY

1) Chrompet industrial area is housing predominantly tanneries and allied chemical industries engaged mainly in manufacturing of chemicals for tannery. The areal extent of study area is 45 sq.km in and around Chrompet.

2) The major surface water body is Pallavaram and Tiruneermalai tanks without its command area and its command area is highly urbanized with residential colonies.

3) The normal annual rainfall is 1247.6 mm, which is contributed by both southwest and northeast monsoons.

4) During pre-monsoon (June-04) in about 52% of wells, Depth to Water Level(DTW) is in the range of 5 – 10 m bgl and in 31% of wells it is in the range of 2 – 5 m bgl. During post monsoon (Jan-05), about 62% of wells DTW is in the 2 – 5 m bgl range and 23% of wells it is in the 0 – 2 m bgl range. The rise in water level, has been observed in all the wells monitored (65 wells), predominantly in the range of 0 – 5 m. Due to the heavy rainfall (205% of normal) occurred during 2005, about 94% of wells showed a rise in water level in the range of 0 – 2 m.

5) The chemical analysis of water samples collected from wells was carried out for both pre-monsoon and post monsoon periods. A significant change in the range of major ionic constituents and heavy metal concentration is noticed after the monsoon.

6) Chromium is the major heavy metal noticed in the study area, which had been the improper waste disposal measures practiced before the establishment of CETP. The significant concentration of other heavy metals like Cadmium and Lead found in the wells near by the tanneries and residential areas suggests that both are responsible for pollution.

7) The higher concentration of Iron and Manganese noticed in some of the wells may be due to natural and industrial pollution, as these metals are noticed in both industrial and residential areas.

8) It is observed that the ground water of the study area is highly polluted with toxic heavy metals besides presence of high TDS and other constituents. This has been mainly due to the improper waste disposal practices adopted at present.

Chapter -7

CONCLUSION AND RECOMMENDATIONS

7.1 CONCLUSION

Based on the attempt made to bring out various issues related to ground water pollution threatening the prospects of sustainable ground water management, the following conclusions are made:

1. Nitrate is one of major indicators of anthropogenic ground pollution. The compilation reveals that ground water in the shallow aquifers in general, richer in nitrate in comparison to the deeper aquifers, establishing the fact that it is directly related to the anthropogenic activities.
2. The study of the analytical results of ground water samples collected from the phreatic aquifers of Tamil Nadu indicates that concentration of Fluoride in excess of permissible limits for drinking water uses in most cases, may be due to the dissolution of Fluoride – bearing minerals in granites and gneisses. It is also observed that ground water in deeper fractured aquifer is more prone to fluoride contamination in comparison to phreatic aquifers.
3. In the state of Tamil Nadu the level of Arsenic in the formation water is much below the permissible limit. The presence of Arsenic is more in phreatic aquifer when compared to deeper aquifer in urban/industrial areas, which may be due to ground water contamination associated with urbanization and industrialization. Comparatively higher amounts of Arsenic is observed in ground water in the vicinity of a few drainage channels as well as possibly due to agricultural/unplanned urban and industrial activities. Thus it is opined that due to uncontrolled anthropogenic activities such as rapid industrialization, urbanization and agricultural practice may increase the Arsenic content in ground water in course of time.
4. In the Manali Industrial area toxic heavy metals are present in the industrial effluents, surface water sources and formation waters. The toxic heavy metal ion concentration is high in areas where the industrial activity is more and is the least where the industrial activity is less.
5. Studies carried out in Dindigul area indicate that the common Effluent Treatment Plant has not been effective in reducing TDS to permissible limit for domestic use. The disposal pond (Sengulam tank) into which the effluents are let out, hence, acts as a point of pollution.
6. Studies carried out in Vellore district reveal that the solid and liquid wastes from the tanneries have caused irreparable damages to water source affecting the local populace and to some extent to the tanneries themselves. The studies also have revealed that the Ranipettai region is an endangered area and warrants strong measures from Government to arrest the deterioration of water quality and prevention of immigration of pollution to new areas and enforcing environmentally sustainable practice by tanneries.

7. Studies carried out in Upper Palar basin reveal that the tanneries in this region now-a-days have switched over to mineral tanning. The untreated effluents, which are indiscriminately discharged from the tanneries have rendered ground water highly polluted.
8. The studies carried out in Tiruppur area, Coimbatore district reveal that the ground water all along the Noyil river is highly polluted and unfit for any purpose. The agriculture lands, which were irrigated with this polluted ground water have become infertile and barren.
9. The studies carried out in Ambattur Industrial area, Tiruvallur district show that toxic heavy metals exceeding the BIS are noticed in fresh water pockets which are confined to very small area. The toxic heavy metals like Chromium, Lead and Cadmium are present in the formation water exceeding many times than the BIS limits. Other heavy metals like Iron and Manganase are noticed in the formation water in about two third of the study area.
10. Studies carried out in Chrompet industrial area, Kancheepuram district showed that the ground water is highly mineralized and excessively hard. Toxic heavy metals were noticed in ground water among which Iron, Lead and Manganese exceeded the limits as per BIS drinking water quality standards.

7.2 RECOMMENDATIONS

The following recommendations are made as a safeguard against further deterioration of groundwater pollution

1) WASTE MANAGEMENT

Lack of proper waste management system in the industrial area is the causative factor and prime source of groundwater pollution. The present method of waste disposal should be modified, since it is not scientifically designed one. Many small-scale industries, which mainly generate solid waste, are dumped on open areas with no consideration of the sub surface conditions. Disposal of effluents by solar evaporation system, reduces the quantum of the waste, but generates sludge, which has to be disposed off properly. Dumping the sludge so generated on to the ground will generates lactates during rainfall and enters in to the aquifer system.

2) DISPOSAL OF WASTES IN TO THE WATER BODIES

At present most of the existing water bodies i.e. lakes, pond and streams are carrying the effluents throughout the years. The two lakes viz. Ambattur and Korratur lakes are almost treated as the dumping sites for effluent disposal. This has severely polluted the groundwater of the nearby areas. Similar is the case of other water bodies. Hence, it is proposed that some clean up activities based on biotechnology utilizing micro organisms may be initiated. Bioremediation techniques may be tried for the selective removal of contaminants.

3) WASTE WATER TREATMENT

Pollution control measures such as effluent treatment plants should be made mandatory for all industries and the concerned authorities should monitor their effective functioning.

Less expensive simple to operate without much skill type of treatment systems should be encouraged. The disposal of wastes on open land especially in unsewered areas and dumping sites needs to be scientifically designed in accordance with the stipulated guidelines.

4) USING SURFACE WATER FOR LIQUIDATION OF POLLUTANTS/AUGMENTING RECHARGE

Ambattur Lake a large tank, which was catering to the irrigation needs of the command area on its down stream direction. Due to urbanization the command area is no more exists and the supply channels were filled up or abandoned. Usually 30% of surface water irrigation in accounted as a contribution to ground water by way of return flow. This flood irrigation is no more existing and the effect will be known once the full fledged housing activities come in to existence. The ground water level may go deeper. Hence, it is suggested to have recharge shaft within the Ambattur Tank at suitable location and just before the MFL, so as to recharge the aquifers in the vicinity of the Ambattur tank. The shaft may be designed to recharge aquifers below 8 to 20 mbgl as these horizons are usually tapped by tube wells in this area.

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